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An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

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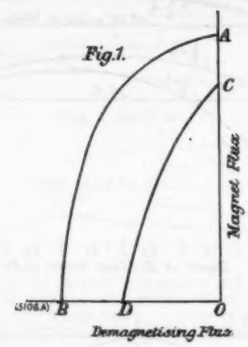
NOTE ON THE TESTING OF MAGNETO MAGNETS.

By J. D. MORGAN, A.M.I.C.E., A.M.I.E.E.

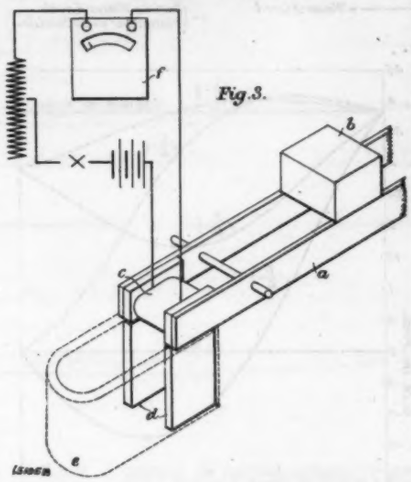
THE testing of the permanent magnets used in ignition magnetos, though apparently a simple matter, presents difficulties of both a scientific and a practical nature. On the scientific side there is no satisfactory criterion of magnetism which is peculiarly suited to magneto conditions, and on the practical side the usual laboratory methods are not readily adaptable to manufacturers' requirements.

In simple, but not very definite language, a magneto magnet must possess both strength and permanence. As a measure of strength it is natural to think of remanence. As a measure of permanence coercivity at once suggests itself. With a good deal of reason in its favour the custom has therefore arisen among some users to specify magnets in terms of remanence and coercivity. For exact measurements of these quantities the ordinary processes of the physical laboratory are doubtless satisfactory, but for practical purposes they are inconvenient. This disadvantage is largely avoided, without materially affecting the accuracy of the results, by the instrument designed by Mr. E. A. Watson, of Coventry. In this instrument a nearly closed magnetic circuit, formed in part by the magnet under test, is provided with a narrow gap in which rotates a metal disc connected to a galvanometer. The galvanometer scale is calibrated in terms of the flux in the gap. By means of windings on the limbs of the magnet this flux can be varied as required. A typical curve is shown at A B, Fig. 1. It will be recognised that this curve forms a portion of the familiar hysteresis loop.



Having obtained the values of remanence and coercivity, the question arises: Can these figures be combined in a single figure which is suitable for defining the magnetic characteristics of the magnet? As is well known, the ratio of the two figures has been suggested, but this is obviously useless. The product has also been proposed, and, whilst it lacks definiteness, it may serve as a practical guide, because it is generally assumed that if a magnet of a given composition shows a certain remanence its coercivity will generally lie between known limits. Some uncertainty is, however, involved in a single characteristic figure of this kind, and if it is deemed necessary to specify remanence and coercivity it is better that they should be specified separately.

Remanence, by its definition, is unquestionably the correct measure of the so-called strength of a magnet, but whether coercivity is a proper measure of the ability of a magnet to retain its magnetism under practical conditions is not so certain. In the absence of any more definite measure it may be prudent to specify coercivity. The main reason for the doubt is found in the experience that increase of coercivity beyond that determined by the design of a particular magneto does not appear to be accompanied by any practical benefits.



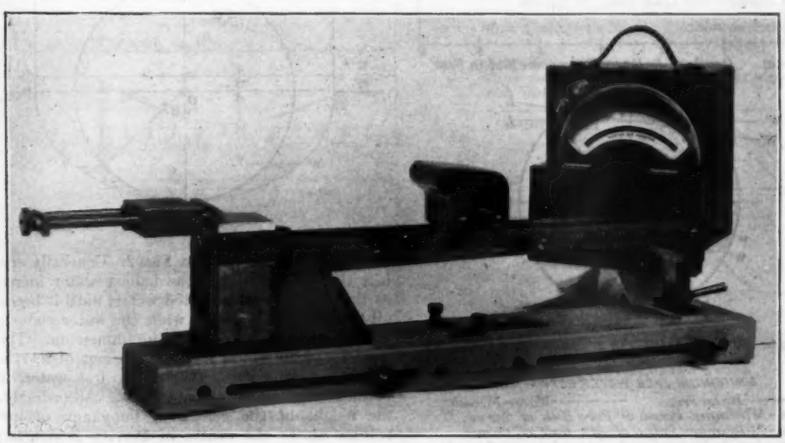


FIG. 2.

The writer recently developed a magnetic balance suited to practical conditions of testing and related in its action as nearly as possible to the duty which the magnet is required to perform. An instrument constructed for Messrs. Thomson-Bennett Magnetos, Limited, to the writer's design is shown in Fig. 2. The scheme is illustrated diagrammatically in Fig. 3. A carefully poised beam *a* carrying a sliding weight *b* has secured to one end an armature *c* which is made from the magnetic portion of a magneto armature and fitted with the usual primary winding. In its normal position the beam rests on a stop which causes the edges of the armature to be separated from the adjacent horizontal edges of the cast-iron pole pieces *d* by air gaps of the thickness commonly provided between the armature and pole pieces of a magneto. The magnet *e* is slipped over the pole pieces as shown. The test is carried out by moving the weight along the beam until the pull of the magnet on the armature is just balanced. This gives a measure of the flux induced in the armature core by the magnet. Then the weight is returned to its zero position and current is passed through the armature winding. On increasing the current a condition is reached in which the opposing magnetism due to the current just balances the magnetism of the magnet, and the beam tips as if acted on by a weight. The reading on the ammeter *f* gives the counterbalancing current. If the test is carried out as follows a curve can be drawn. First the weight is moved to the position at which it counterbalances the magnet flux. Then it is moved a short distance along the beam towards the zero position and current is passed through the winding and adjusted until the beam is deflected. This operation is repeated at different positions of the weight until the latter reaches its zero position. The square root of the beam-scale readings is then plotted against current. A typical curve is shown by C D, in Fig. 1. The two curves are not drawn to the same scale; they are simply shown together to illustrate the argument given hereunder.

A characteristic of the test is that the permanent magnetism of the magnet should not be affected by it, or only slightly. This will be found by repeating the first part of the test after the current producing the opposing magnetism has been stopped. If variation be shown, repetition of the test should bring the magnetism to a steady state. When, after repetition, both beam and current readings are below the permissible minima, the magnet is rejected.

It is evident that the area of the curve O A B (Fig. 1) represents the total energy put into the magnet. If an ideal machine could utilise the whole of that energy the area of O A B is the measure of the energy that would appear in the spark. Such a machine could, however, only give one spark, and before it could give another equal to it the magnet would require remagnetising. The area O C D also represents energy, but as the same magnet is capable of reproducing the same curve indefinitely without remagnetisation, it follows that the area represents the energy which an ideal machine can convert into a spark repeatedly without diminution. It is permissible, therefore, to compare the curves with the work diagrams obtained in stressing a metal bar (1) to the breakdown point and (2) to the elastic limit. The foregoing contains the reason for the statement in the earlier part of this article that increase of coercivity beyond a given figure does not appear to increase the durability of the magnet in its operation on a particular machine. Provided the coercivity figure of a magnet is above that corresponding to the maximum demagnetising action which can be produced in the magneto, there is no apparent reason why this magnet should deteriorate in service.

An obvious criticism of the magnetic balance above described is that it does not exactly reproduce magneto conditions, seeing that the armature carried by the beam is situated above the pole edges instead of between the poles. The reply is that it is not possible to adopt the ordinary magneto relationship of the armature and pole pieces and at the same time obtain a perfectly definite indication of the state of balance when the proper demagnetising current is applied. By arranging the armature in the manner illustrated this condition is avoided.

THE JAPANESE SOCIETY OF NAVAL ARCHITECTS.

THE twentieth annual meeting of this society was held on September 17 last. The annual report was first read, and showed that 1,010 members were on the roll and the funds in hand amounted to 44,000 yen.

The presidential address by Baron Akamatsu was optimistic, but not boastful, as the following abstract indicates:—At present Japanese shipbuilding is unusually active, the ships launched during the year dealt with having a gross tonnage of over 245,000 tons; orders on hand made up nearly 590,000 tons. By a comparison of these figures with the 99,000 tons launched in 1914, and also with the 440,000 tons built during the last 18 years under the Shipbuilding Encouragement Act

(a liberal subsidy is given in Japan for home-built ships of 1,000 tons and above), there is obviously rapid improvement of Japan shipbuilding. However, said the president, "we must not be too optimistic; this brisk state is merely the consequence of the present war. If we are not prepared to meet foreign competition after peace is regained, the prosperity will not last long."

The following papers were read and discussed: "The Stability of Submarine Boats while Trimming," by Commander-Constructor S. Motohara; "On Mixed firing for Marine Boilers," by Mr. A. Mitsuhashi, of the Toyo Kisen Kaisha; and "Hints Regarding the Corrosion of Marine Boilers," by Mr. T. Saito, an engine surveyor of the Department of Communications.

The Stability of Submarine Boats while Trimming.

Commander-Constructor S. Motohara's paper dealt principally with the changes of the initial stability of the submarine boat while her water-ballast tank is being filled. As the "loss of buoyancy" method is more suitable than the "added weight" one for calculation in such a case, the author adopted the former method throughout his paper. As shown below, his investigation was mostly concerned with submarine boats having mathematical forms, though actual boats, also, were not left untouched.

A. *Single-Hull Type.*—Three different forms were investigated:—

(1) *Circular Cylindrical Form.*—According to the author, it is hardly necessary to say that the

$$\text{Righting couple} = W_0 \times G\,M \times \sin\theta,$$

in which W_0 is the original displacement, G M the metacentric height and θ the angle of heel.

(2) *Elliptic Cylindrical Form.*—An analytical solution was made for an ideal case where no ballast tank is provided, but the water is admitted freely into the vessel. The result of calculation was shown diagrammatically (Fig. 1) for a boat having the following dimensions: Major axis of the section (this being horizontal), 12 ft.; minor axis of the section, 6 ft.; initial draught, 3 ft. (Centre of gravity of the boat was supposed to be at the centre of the section.) Three different lengths of floodable space were taken, namely, the proportion of its length to that of the boat 1, $\frac{1}{2}$ and $\frac{1}{4}$. It was shown that, as flooding went on, the initial stability decreased until it attained its minimum value when the external and internal water-levels coincided, and thence it gradually increased.

(3) *Actual Vessel.*—The author did not fortify the above by any data derived from an actual vessel. However, he stated: "With regard not only to the stability, but also to the strength, an elliptic vessel is far inferior to a circular one. The inferences drawn from the above calculations cannot be directly applied to an actual vessel, because in an actual case the water is not allowed to fill the internal space freely, but is admitted into ballast tanks of limited space, as shown in Fig. 2. Generally speaking, the free surface of the ballast water increases as the quantity of admitted water, until it becomes nil when the tank is full, while the water-plane area of the vessel decreases with the immersion. Therefore, $I - i$, in which I is the moment of inertia of the water plane and i that of the free water, may become negative in some vessels. Accordingly, if the height of the centre of buoyancy of intact volume above the centre of gravity is not larger than $\frac{I - i}{V_0}$, such a vessel may show a large heel, though it does not generally incur danger, because the time of flooding is generally short and a large heel is generally accompanied with a large righting moment.

B. *Double-Hull Type.*—The author stated that in a double hull-type the effect of free ballast water was more profound than in a single-hull type, because in the former the weight and moment of the ballast water was larger than in the latter. He made calculations on the following forms:—

(4) *Vessel of Elliptic Section* having a circular inner hull, containing ballast water between inner and outer hulls. The following figures were applied to an analytical solution: Major axis of ellipse (breadth), 12 ft.; minor axis of ellipse (depth), 6 ft.; draught, 3 ft.; diameter of inner hull, 6 ft. (Centre of gravity at the centre of section.) Two different cases, in one of which the tank is extended over the entire length of the vessel, and in the other over the half-length, were calculated; the results are given in Fig. 3. It was shown that the general nature of the change of initial stability was similar to that of an elliptic single-hull type, with such a difference that the minimum point in this case does not occur when the internal and external water-levels coincide.

(5) *Vessel of Rectangular Section* having cylindrical

Fig. 1. CURVES OF INITIAL STABILITY FOR VESSEL OF ELLIPTIC SECTION, CONTAINING FREE WATER.

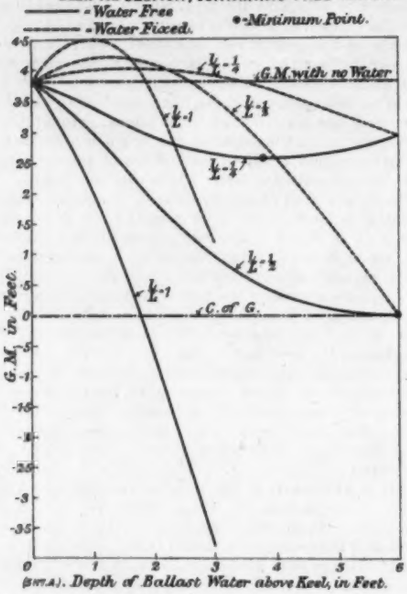


Fig. 3. CURVES OF INITIAL STABILITY FOR VESSEL OF ELLIPTIC SECTION HAVING CIRCULAR INNER HULL, CONTAINING FREE WATER BETWEEN INNER & OUTER HULLS.

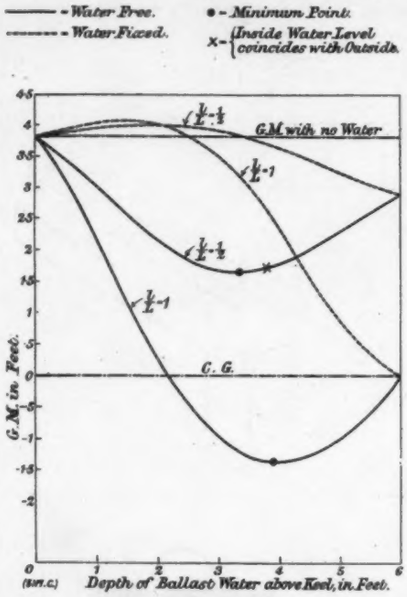

——— = Water Free.
------- = Water Fixed.
• = Minimum Point.
X = Inside Water Level coincides with Outside.
G.M. with no Water
C. G.
G.M. in Feet.
(SHT. C.) Depth of Ballast Water above Keel, in Feet.

Fig. 4. CURVES OF INITIAL STABILITY FOR RECTANGULAR VESSEL HAVING CYLINDRICAL INNER HULL, CONTAINING FREE WATER BETWEEN INNER & OUTER HULLS

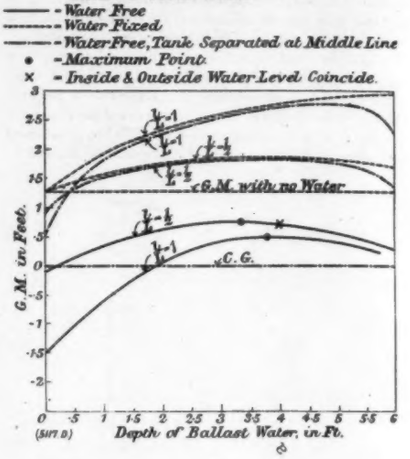

——— = Water Free
------- = Water Fixed
——— = Water Free, Tank Separated at Middle Line
• = Maximum Point
X = Inside & Outside Water Level Coincide.
G.M. with no Water
C. G.
G.M. in Feet.
(SHT. D.) Depth of Ballast Water, in Ft.

Fig. 2.

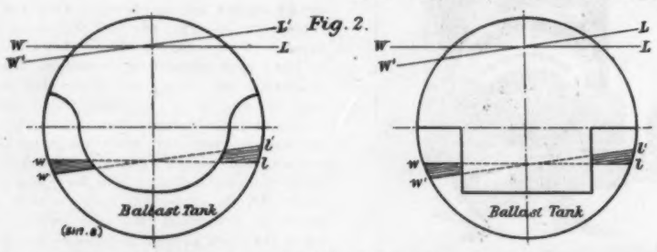


Fig. 5

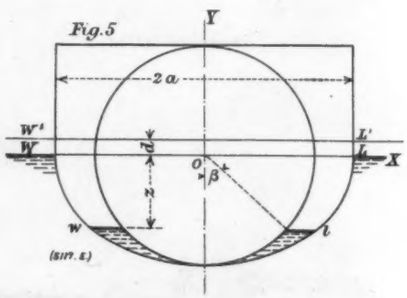
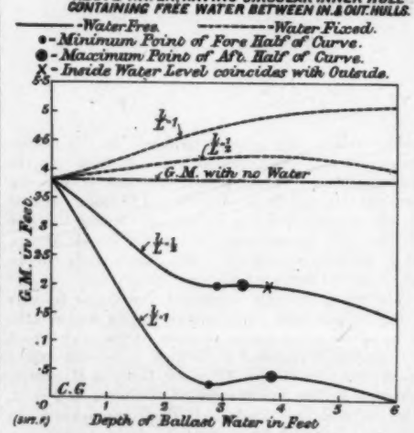


Fig. 6. CURVES OF INITIAL STABILITY FOR VESSEL OF ELLIPTIC SECTION UNDER WATER, RECTANGULAR ABOVE WATER, HAVING CIRCULAR INNER HULL CONTAINING FREE WATER BETWEEN IN & OUT. HULLS.


——— = Water Free. ——— = Water Fixed.
• = Minimum Point of Fore Half of Curve.
• = Maximum Point of Aft. Half of Curve.
X = Inside Water Level coincides with Outside.
G.M. with no Water
C.G
G.M. in Feet.
(SHT. F.) Depth of Ballast Water in Feet

inner hull, containing ballast water between inner and outer hulls. To an analytical solution he obtained the following data were applied, and the result was as shown in Fig. 4: Breadth, 10 ft.; depth, 6 ft.; draught, 3 ft.; diameter of inner hull, 6 ft. (Centre of gravity at the centre of section.) As before, two cases, in one of which the tank is extended over the entire length of the vessel, and, in the other over the half-length, were calculated. It was shown that the initial stability was negative at the beginning and gradually increased to a maximum value just before the ballast water-level reaches the water-line; and also that if the size of the flooding valves was small and, consequently the tanks on both sides behaved as independent ones, the ballast water might be regarded as fixed.

(6) *Vessel of Elliptic Section under Water and Rectangular above*, having a circular inner hull, containing ballast water between inner and outer hulls (Fig. 5). The following dimensions were taken and applied to an analytical solution, its result being shown diagrammatically in Fig. 6: Breadth (or major axis of the ellipse), 12 ft.; depth (or minor axis of the ellipse), 6 ft.; diameter of inner hull, 6 ft.; draught, 3 ft. (Centre of gravity at the centre of inner hull.) Again two different lengths of tanks were taken. As might be anticipated, the nature of the curves is midway between that in the cases (4) and (5).

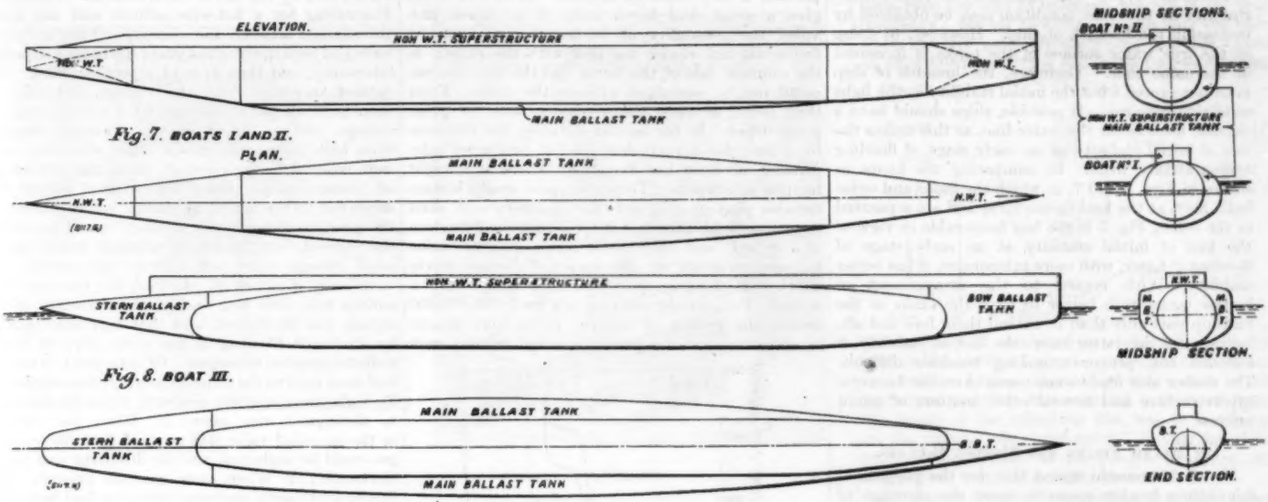
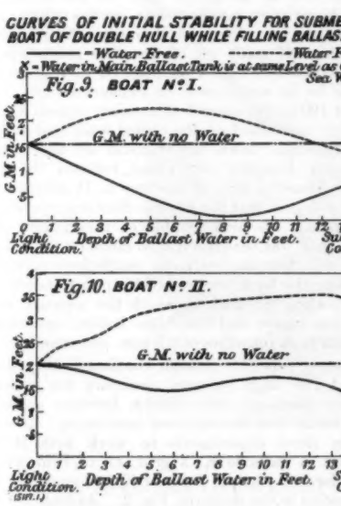


Fig. 7. BOATS I AND II.

Fig. 8. BOAT III.


CURVES OF INITIAL STABILITY FOR SUBMERSIBLE BOAT OF DOUBLE HULL WHILE FILLING BALLAST TANKS.
——— = Water Free. - - - - - = Water Fixed.
X = Water in Main Ballast Tank, is at same Level as Outside Sea Water.
Fig. 9. BOAT No. I.
G.M. with no Water
G.M. in Feet.
Light Condition.
Depth of Ballast Water in Feet.
Submerged Condition
Fig. 10. BOAT No. II.
G.M. with no Water
G.M. in Feet.
Light Condition.
Depth of Ballast Water in Feet.
Submerged Condition.

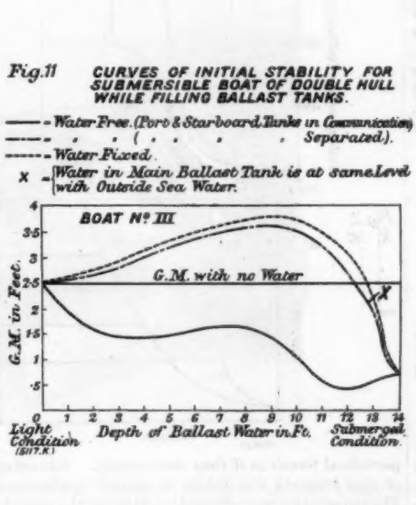
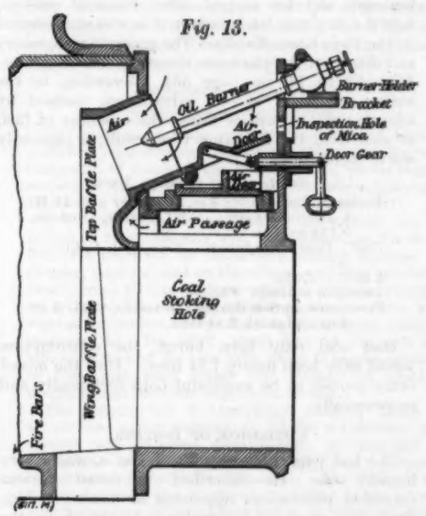
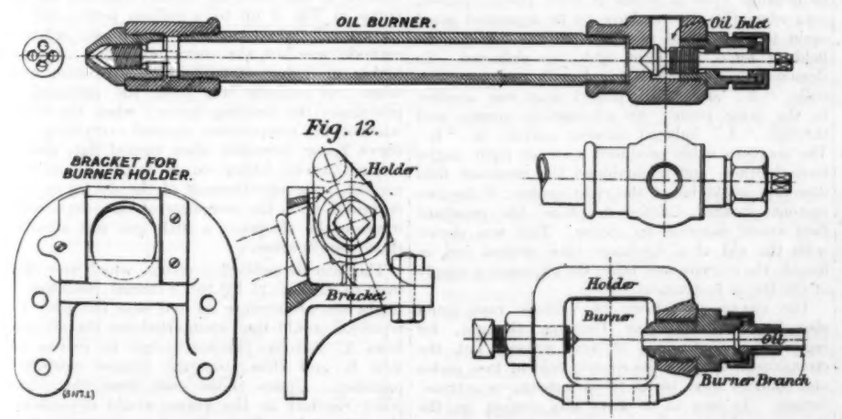


Fig. 11 CURVES OF INITIAL STABILITY FOR SUBMERSIBLE BOAT OF DOUBLE HULL WHILE FILLING BALLAST TANKS.
——— = Water Free. (Port & Starboard Tanks in Communication)
- - - - - = " " (" " " Separated).
------ = Water Fixed.
X = Water in Main Ballast Tank is at same Level with Outside Sea Water.
BOAT No. III
G.M. with no Water
G.M. in Feet.
Light Condition
Depth of Ballast Water in Ft.
Submerged Condition





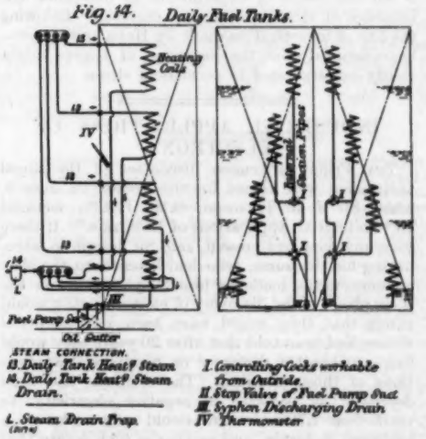


Fig. 14. Daily Fuel Tanks.
Heating Coils
Fuel Pump Suct.
Oil Cutter
STEAM CONNECTION.
13. Daily Tank Heat? Steam.
16. Daily Tank Heat? Steam. Drain.
L. Steam. Drain. Prop.
I. Controlling Cocks workable from Outside.
II. Stop Valve of Fuel Pump Suct.
III. Syphon Discharging Drain.
IV Thermometer

(7) *Actual Double-Hull Vessel.*—First, two types of vessels (Fig. 7) were taken, one having an elliptic outer hull (No. I) and the other having a ship-shaped outer hull (No. II). The result of calculation was as shown in Figs. 9 and 10. As might be foreseen, much similarity exists between the curves in Figs. 3 and 9, and also between those in Figs. 6 and 10.

Also curves for a type of vessel (No. III) as shown in Fig. 8 were obtained (Fig. 11).

In connection with the shape and arrangement of ballast tanks the author stated his view on the shape and arrangement of the ballast tanks of double-hull type. The increase of the initial stability at the light condition may be obtained by increasing the breadth of ship. However, in doing so the free water surface of the tanks is increased at the same time. Therefore, the breadth of ship must not exceed what the initial stability at the light condition requires. If possible, ships should have a circular form under the water-line, as this makes the loss of initial stability at an early stage of flooding comparatively little. In comparing the forms as shown in Figs. 8 and 7, in which the inner and outer hulls meet at the keel in one form and are separated in the other, Fig. 7 is the less favourable in view of the loss of initial stability at an early stage of flooding. Later, with more submersion, it has better stability. With regard to the arrangement of ballast tanks, it is better to have the tanks at the midship part only than to extend them fore and aft, because in the latter case the initial stability is lessened and proper trimming becomes difficult. The author also made some remarks on the Laurenti superstructure and several other matters of minor interest.

On Mixed Firing for Marine Boilers.

Mr. A. Mitsuhashi stated that for the purpose of minimising bunker space to meet the shortage of tonnage, and for several other financial reasons, mixed firing was lately adopted in steamers owned by the Toyo Kisen Kaisha. The general arrangement and details of the plant are shown in the diagrams, Figs. 12 to 14, on page 561. According to the author, amongst several advantages realised by adopting this system of firing, the economy of fuel, as seen from the following trial result, is especially worth mentioning.

Trial Results of the Kiyo Maru.

Boilers: Four 14 ft. 3 in. diameter and 11 ft. 6 in. in length; total heating surface, 9,124 sq. ft.
Fuel: Coal, Shinyubari; heavy oil, California oil.
I.H.P.: 2,665.
Duration of trial: 3 hours.
Fuel consumption during the trial: Coal, 3.10 tons; plus oil, 2.81 tons.

Had coal only been burnt, the consumption would have been nearly 7.14 tons. Thus the mixed firing proved to be successful both technically and economically.

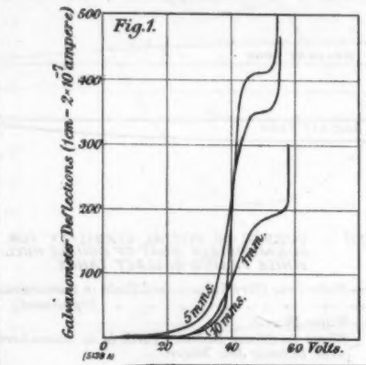
Corrosion of Boilers.

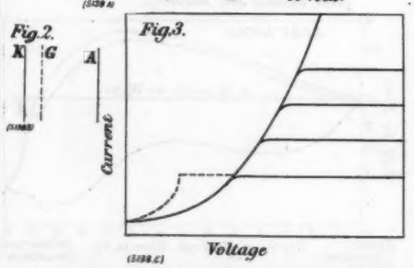
The last paper, read by Mr. T. Saito, was a very lengthy one. He described in detail various corrosion phenomena appearing in marine boilers. From the result of experiments to determine the influence of tensile stress upon corrosion—following the line of investigation made by Heyn and Bauer—he concluded that the corrosion of boilers might chiefly be attributed to permanent stress.

INDUSTRIAL APPLICATIONS OF ELECTRONS.

The Friday afternoon discourses of the Royal Institution were closed for this season on June 8, when Sir J. J. Thomson, O.M., P.R.S., lectured on "Industrial Applications of Electrons." If there were any members present, said Sir Joseph in introducing his discourse, who had listened to the first announcement, made by him 20 years ago, in the same place, of the discovery of electrons, they would admit that they would have been very sceptical if they had been told that after 20 years they would listen to another discourse on commercial applications of those electrons. The electrons had been described as particles of negative electricity, so small that 1,700 of them would only make up a hydrogen molecule, and moving at such a rate that they would only exist for the hundred-millionth of a second in a discharge tube. Such properties appeared rather of a transcendental character and not promising from a practical point of view. But, as a matter of fact, electrons were now in trade catalogues, and, what was worse for the lecturer's purposes, also in the law courts, and if he referred only to very few names in his discourse, it was not his wish, but ignorance of the law; he would not like to attribute to A what the courts had assigned to B.

The electrons had properties which were important if they could be utilised. Inventors would give a great deal for a body of no mass, provided the possibility of its being acted upon by forces did not vanish together with the mass; in the common case of the horse and the hay, the one could not be sustained without the other. From that point of view the electrons were of great possibilities. In the second instance, the electrons lived only for a very short period, and were independent of what had happened before and might happen afterwards. Thus they gave really instantaneous photographs, not like pointers and dials for averages of seconds, but for a very small fraction of a second, and they were hence of great value for measurements of the forces of electric waves which were changing their directions many times a second. For particles existing only for 1/100,000,000 second the periods of electric waves were almost an eternity, and the particles would register such





periodical forces as if they were steady. Advantage of this property was taken in several applications. The registration was effected by allowing the particles to impinge upon a screen of some platinocyanide, *e.g.*; when the electric force to be measured acted upon the stream of particles passing through the field of force, the light spot was deflected. To demonstrate this effect Sir Joseph had two wire coils, "A" and "B," placed near one another in the same plane; an alternating current sent through "A" induced another current in "B." The magnetic fields produced were at right angles to each other, and if combined the resultant field direction would bisect the right angles; if the two currents further differed in phase, the resultant field would describe an ellipse. This was shown with the aid of a discharge tube several feet in length, the current used being the alternating supply of the Royal Institution.

The stream or column of cathode rays could also be used, Professor Thomson thought, for registering continuous electric waves. Let the stream pass through the electric field of two plates and connect these plates to an antenna or a transformer. As long as no wave was coming on, the stream would flow along steadily; when the waves came, the spot would be drawn out into a straight line. If the waves were continuous, the illumination along that line would be uniform; if the waves were cut up into dots and ashes, the dashes would show quiescent bright spots of longer duration than the dots. There were other ways of registering the arrival of electric waves by electrons, and tens of thousands of such apparatus were already probably in use. In these apparatus a stream of electrons was liberated by heating a wire of tungsten or a strip of platinum coated with lime; the particles were emitted at low speeds, but could be accelerated by the use of electric fields. The curves illustrating for a hot-wire cathode and any anode the relation between the current and electromotive force had been determined years ago in the Cavendish laboratory, and they were of a peculiar kind. The current increased with the voltage, but (Fig. 1) then bent off flatly, so that for a time increase of voltage had no effect on the current. Starting from high volts, this meant that, when the volts were reduced below a certain value, the current fell off tremendously. When the external voltage was subjected to the action of electric waves, therefore, the positive phase of the message would not affect the current, but the negative phase would, and a small change could not increase the current, but could only diminish it. If then the message were cut up into dots and dashes, the detection of the signals was facilitated, and that had been applied by Professor Fleming in the early days to detect radiotelegraphic messages. Of late great attention had been paid to the improvement of these detectors. To make these matters clearer it would be advisable to distinguish two cases: (1) When the vacuum in the so-called valve was so good that the residual gas could be neglected, and the discharge was purely electronic; (2) When some gas was present. The first case of purely electronic discharge had been especially decided by Langmuir with the aid of the remarkable mercury condensation pumps which we described in our issue of January 26 last; Sir Joseph himself made use of the glass pump which was illustrated in Fig. 4 on page 83 of that issue. The gas to be withdrawn, he explained, met the rush, at 100 m. per second, of mercury vapour which was being condensed on the cooled walls and which carried the gas down for removal by the rough pump. Sir Joseph's own pump reduced the gas pressure from 0.5 mm. of mercury in 1½ minutes to so low a degree that the electric discharge would no longer pass. The one trouble of this pump, the lecturer said, was that it relied so much on the rough pump; to attain the realisable marvellous rapidity of working the back pressure of his pump should be ½ mm.; when the flask in which the mercury was boiled was bigger and the flame hotter, one could work with back pressures of 0.5 mm. and even 1 mm.

Supposing now, Sir Joseph continued, they had obtained the high vacuum necessary for purely electronic discharge, the relation between current and potential then became very interesting. It was usual in these experiments to work with three electrodes, a cathode K, a grid, G, of bent wire, or a perforated plate in front of K, and an anode A, somewhat as in the diagram, Fig. 2. As long as the cathode K was cold, the current followed the main curve in Fig. 3 up to a certain point, and then turned off flat in a horizontal line; when the cathode was hot, the curve proceeded to a point higher up before it turned off. In other words, when the cathode was cold, the potential was practically the deciding factor; when the cathode was hot, the temperature decided everything. The curve hence ascended, then turned flat, and any electric waves falling on it would diminish the current; the sensitiveness of the device to waves depended upon the steepness of the curve, and to increase the steepness a little gas was admitted; thus case (2) arose.

The cathode emitted electrons, which were driven over to A (Fig. 2) by the external potential, but might also accumulate on and near the grid; their repulsion would then counterbalance the attraction from A, and the particles would be driven back into K and thus stop the further emission of particles. Under those conditions the highest point reached in the curve would depend upon the potential applied. But it was possible to increase the steepness of the curve. When a little gas was admitted between A and G, a few positive ions would be produced, and they would move slowly (being more massive than the electrons) and remain almost stationary, neutralising some of the electrons near the grid, through the perforations of which they could pass; the grid

THE DUMORE PORTABLE GRINDER.

CONSTRUCTED BY THE WISCONSIN ELECTRIC COMPANY, RACINE, WISCONSIN, U.S.A.

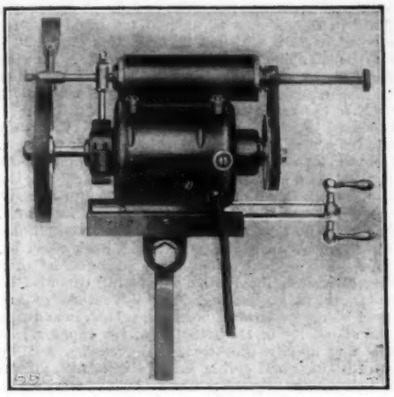


FIG. 1.

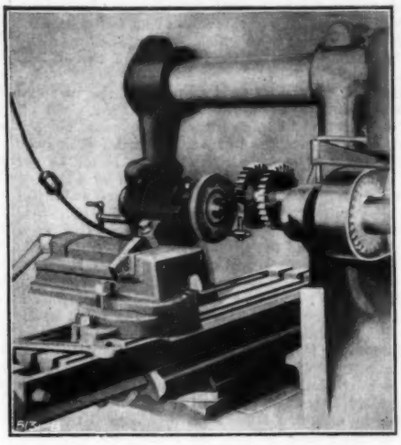


FIG. 2.

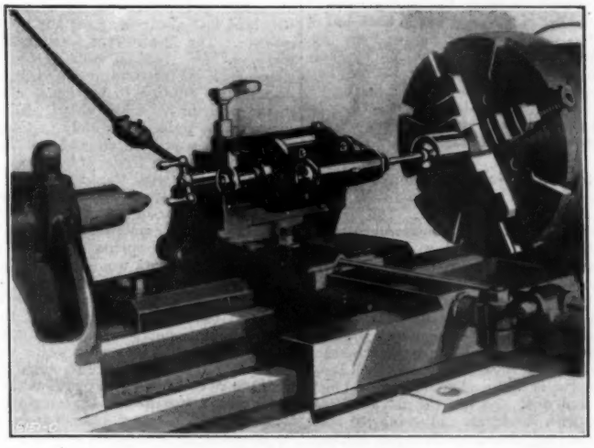


FIG. 3.

must not be too close for this reason. The effect was therefore that more electrons could be emitted by K, and the current curved (in the dotted line of

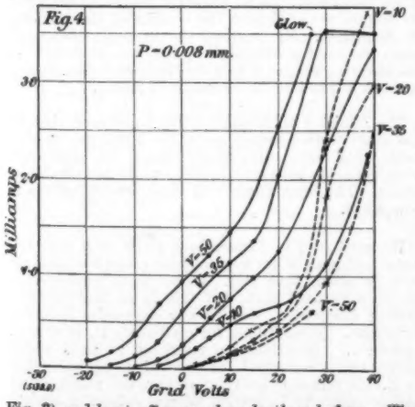
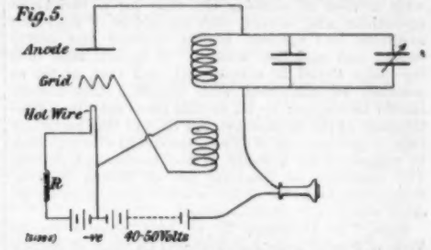


Fig. 3) and bent off more sharply than before. The suitable potential relation was given by the equation: grid potential / anode potential = $n^2m/4M$, where n was the number of positive ions produced per electron, m the mass of an electron, and M the mass of a positive ion. With this arrangement the grid might even be negative to the cathode; the grid would still facilitate the further emission of electrons, provided the lines of force could pass through the perforations; Fig. 4 shows the curves obtained with external potentials up to + 50 volts and grid potentials ranging from − 20 to + 40 volts. Another method of obtaining high sensitiveness was to work at higher gas pressure with the help of ionisation; when the gas was ionised the current rose at tremendous rapidity. In that case the condition for the most sensitive state was:—

$$\frac{\delta i}{i} = \frac{1}{1.8}\,\frac{\delta E}{Q},$$

where i was the current, δi the change in the current, and δE the change in the grid potential. Those devices were, however, subject to the one drawback that with intense ionisation, which would become apparent by the bluish glow, the ions struck the glowing tungsten wire, and that was fatal to the wire.

All these devices served for the registration of small changes in currents received. But electrons could also, in so-called heterodyne apparatus, be utilised for producing continuous electric waves. The idea was that of the pendulum clock and escapement. The pendulum oscillated at a definite rate, but without the aid of the escapement the oscillations would die away. One of the ways in which continuous waves could be produced was indicated in Fig. 5; the condenser and anode circuit corresponded to the pendulum, the circuit of the battery, grid and hot wire to the escapement. This arrangement was now largely used. Suppose the waves received were of 50,000 periods, the waves imposed upon them were of nearly the same period, say, 49,000 periods, and the resulting waves represented the difference, waves of 1,000 periods. An acoustical analogue would be formed by two bird calls, each too high to be heard, but not of the same frequency; the ear should be able to hear the beats when the two notes were sounded together. Such an experiment not being suitable for a lecture room,



Sir Joseph had combined two whistles, shrill, but just audible, with a resonator tuned to the difference in period. A soap film closed the mouth of the resonator, and this film reflected a beam of light; the image of the vibrating film was to be thrown on the screen. An "evil spirit" having interfered with his apparatus, as Sir Joseph remarked, the experiment was not actually shown.

Sir Joseph concluded by stating that the applications of electrons were a good example of the sound principle: never restrict scientific investigation by considerations of utility; the best way to advance science was to leave it free to go on.

PORTABLE GRINDER.

ON the present page we illustrate a very handy portable grinder constructed by the Wisconsin Electric Company, of Racine, Wisconsin, U.S.A., whose representatives in London are the Canadian-American Machining Company, of 8, Bouverie-street, E.C. As will be seen from the engravings, the grinder can be bolted on to almost any tool, for instance, on the slide rest of a lathe, on the frame of a planing machine or shaping machine, and on the arm of a milling machine. It will grind milling cutters—whether angular, straight or spiral—while on the spindle of the machine, will regrind cylinders, deep drawing dies, large gauges, reamers, &c. Its chief merit lies in its extreme adaptability and the ease with which it can be applied to tools and work which are already on another machine, and therefore require no setting.

The construction is exceedingly simple. There is an electric motor running at 10,000 revolutions per minute, and balanced dynamically. At one end of the spindle is the emery wheel, and for many purposes this constitutes the entire apparatus. The bearings for a second spindle can, however, be bolted to the frame, and the spindle be driven by a belt at 30,000 revolutions per minute. The second spindle has a long extension, enabling it to do internal grinding of very considerable depth. All the bearings have balls, and are guaranteed to run without shake or tremor. The current for the motor, either direct or alternate, is taken from the nearest lamp socket, and the total weight of the apparatus is 17 lb.

SYNTHETIC GASOLINE IN THE UNITED STATES.—We have repeatedly referred to the gasoline cracking process of Dr. W. F. Rittman, and we have heard critical comments on this process and doubts as to its efficiency. In a paper, read in April last before the Kansas City meeting of the American Chemical Society, entitled "One Billion Gallons of Synthetic Gasoline in 1918," Rittman mentioned, however, that 600,000,000 gallons of gasoline would be prepared in the United States in 1917, and the production would reach 1,000,000,000 gallons in 1918. That was necessary to meet the ever-increasing demand. The number of automobiles in the United States had risen to 4,000,000, and was growing at the rate of more than 40 per cent. yearly; each of these consumed about 500 gallons of gasoline per annum, and motor boats and cycles, farmers, dyers, cleaners, chemists, &c., made further heavy claims. The gasoline recovery from natural gas had increased from 7,000,000 gallons in 1911 to 200,000,000 in 1917, the crude oil production from 135,000,000 gallons in 1905 to 292,000,000 gallons in 1916, the gasoline production from 7,000,000 gallons in 1904 to 70,000,000 gallons in 1917 [we give round numbers]. The extensive demand had been met by taking a larger portion of motor fuel from the crude oil and calling it gasoline, and by cracking heavy oils for gasoline, but it is indeed a question of general economy how much further the supply of petroleum should be placed at the disposal of the synthetic gasoline manufacturer.

MACHINES AND APPLIANCES FOR MUNITION-MAKING.

In supplement to the particulars given in our article on the King's visit to munition factories (page 492 *ante*), we give to-day, on Plates LXI to LXIV, a series of illustrations of special munition machines and of the crane equipment for such machines. Great ingenuity has been exercised in order to devise a type of machine adapted to the special requirements, first, with a view of utilising the type for a variety of operations, and, second, with the object of rendering available and efficient women workers and partly skilled and unskilled workers. It is well that such ingenuity should be commended, and that, as far as possible, all connected with munition manufacture should be inspired by it, so that there may be a continuance of the application, not only of this particular type of machine but of others, the design of which may be suggested by a study of the mechanical details. The machines we illustrate are of Messrs. Vickers' design, and are in use in one or other of the factories we dealt with in our previous article.

Figs. 1 to 14, Plates LI to LIII, show a special Vickers' type of lathe manufactured for them at Barrow and elsewhere. Working drawings of it have also been supplied to the Lancaster Ordnance Accessories Company and to the Ministry of Munitions. The main features of the design are simplicity, strength, adaptability and compactness. The third, in particular, of these qualities is well illustrated by the figures we publish. The various groups of illustrations, Figs. 2 to 7, Figs. 8 to 10, and Figs. 11 to 14, show machines respectively arranged for trimming off the rough end, boring and facing the nose, and screwing the base of the interior for the adaptor, of large shells. A glance at the illustrations will show that the machines for these various very different operations are in their main features identical. No doubt an ordinary engine lathe, with a suitable chuck, would be equally capable of carrying out these three operations, but an ordinary engine lathe is a much more complicated and expensive machine than that with which we are dealing, and would occupy considerably more floor space. On the first of these two points it may be said that this Vickers' lathe has an average cost of only about 100*l*., whereas a standard machine to do the same work would cost anything from 200*l*. to 500*l*. or over. The second point, that of saving of floor space, is clearly illustrated by the compact design, which is well shown by our illustrations.

It will not be necessary to describe each of the various forms of the machine in detail. A brief sketch of one will enable the others to be fully understood from our figures. As a characteristic machine we may deal with the simplest form—that illustrated in Fig. 1, and shown in detail in Figs. 5 to 7, and intended for parting off the rough end of the shell forging preparatory to turning the outside and boring the interior. This parting off, which in shop terms is usually known as "ripping," is the first operation performed on the shell after it is received by the machine shop from the forge. Turning to Figs. 5 to 7, it will be seen that the lathe consists of a simple box-bed and two cast-iron side frames which carry the bearings for the main and pulley spindle. The main spindle is of large diameter and hollow, and is driven by a single reduction gearing from the pulley spindle. The latter is fitted with fast and loose pulleys, so that the machine requires no countershaft. The belt control fork is operated from a hand lever mounted on the machine frame. The hollow spindle is of sufficient internal diameter to take the shell forging, and is of such length that when the shell is nested in it the projecting end is in a convenient position for being operated on by a parting tool carried in the rest.

The shell is held in the spindle and driven by pinching screws as shown. As will be seen, the tool rest is carried on a block bolted directly to the box-bed, and is fitted with both cross and longitudinal traverse. The cross traverse, which is, of course, used for parting off, is fitted with a ratchet feed gear, the feed-ratchet pawl being driven from a reciprocating shaft carried on the front of the bed and operated from a crank pin on the outside end of the main spindle. It may be said that experience has shown that the girls who operate these machines prefer to feed by hand. This method of working entails no change in the machine.

The lathe, exactly as described above, is suitable and is used for facing the base of the shell as well as ripping the open end, while a similar type of machine, built for a smaller class of shell, is illustrated in Figs. 2 to 4. In this case no ratchet feed gear is fitted. When facing the base greater accuracy in setting up is necessary, since the shell is turned and bored before this operation. To facilitate this setting up a ring hollowed out cone-shaped is fixed at the back end inside the hollow spindle. The nose of the shell fits into the cone and the back end of the shell is thus automatically centred. A drawback screw is used to pull the shell into the cone.

For facing and boring the nose the machine takes the form illustrated in Figs. 8 to 10. As will be seen, the principal modification introduced is the fitting of the kicker feed gear on to the longitudinal traverse instead of the cross traverse. The boring is of course the main part of this operation, the facing being a small job which can easily be carried out with the hand feed. To facilitate centring in this case a cone is fitted inside the hollow spindle, on to which the bored-out open end of the shell fits, so that the back end of the shell is automatically centred.

The lathe for the internal screwing of the base end of base adaptor shells is illustrated in Figs. 11 to 14. The construction in this case is a little more complicated, but the machine in its main lines remains the same. The tool rest, instead of being bolted to the bed, is arranged to slide, and is operated by a leading screw driven by a train of wheels in the usual way. On the pulley spindle there are two pinions of different sizes, one or other of which may be thrown into action by a dog clutch. One of the pinions drives the main spindle through an idle wheel, and the other drives it direct. The result of this is that as the clutch is thrown over the direction of rotation of the main spindle is reversed. A special feature of the machine is that the nut which traverses the slide rest is a solid nut, and is always in position on the leading screw, so that it is impossible to get the rest out of pitch with the thread which is being cut, as might be possible were a split nut used. This point is an important one, as the lathes are operated entirely by unskilled labour. If it is desired that the slide should remain at rest, the leading screw-driving train is thrown out of action by a lever, which can be seen at the front of the machine at the left-hand side. A square turret is fitted, and four tools are required to carry out the full operation which the machine has to perform. These consist of recessing at the back end of the thread, counter-boring, screw-cutting and chasing. With the different-sized pinions on the pulley shaft the machine runs at different speeds in the two directions. The quick speed is used only for traversing the tools into position, and all cutting is done on the slow return. This machine, as well as the others we are describing, has proved very satisfactory in the hands of girls.

Two other details used in connection with this Vickers' lathe are illustrated in Figs. 15 to 17, Plate LXIII, and Figs. 21 to 23, Plate LXIV. The first of these devices is an ingenious and simple screwing attachment for cutting the thread in the base of shells with screwed baseplates. This appliance is self-contained, and is held in the tool rest. It consists of a pair of levers which can be brought together, or moved apart, by a toggle with a handle. One lever carries a half-nut which gears with a thread cut on the outside of the nose of the main hollow spindle of the lathe, while the other carries a chaser which cuts the thread in the shell base. The whole attachment is arranged to slide on a block attached to the tool rest. To use the device it is placed in position with the levers embracing the shell end; the toggle is then closed so that the half-nut engages with the thread on the spindle and at the same time the chaser comes in contact with the interior of the baseplate recess. The whole arrangement then travels along owing to the rotation of the lathe spindle and the engagement between the half-nut and the thread on the spindle nose, with the effect that the chaser produces a thread of similar pitch on the shell. The depth of thread cut is regulated by the adjusting screw shown in Fig. 16. It will be clear that this device enables the base end of shells to be threaded in a simple non-screw-cutting lathe.

The other detail, Figs. 21 to 23, is a simple davit, which is attached to the front of one of the side frames of the lathe. It is fitted with a lifting drum having a ratchet detent. With this davit a girl can lift a rough 9.2-in. forging into a ripping machine. These davits have mainly been introduced to reduce the work required from the overhead cranes and to render the lathes largely independent of them. They have done much to increase output. The lathes illustrated in Figs. 1 and 8 are all fitted with them.

A similar device, employed in connection with lathes of a more ordinary type, is shown in Figs. 19 and 20, Plate LXIV. This is a crane with a swinging jib and fitted with the same type of lifting gear as that just described. This crane is usually set to serve two lathes, swinging over one to feed that behind. There is no travelling monkey on the jib, the crane being so set that the shell being lifted swings exactly into the lathe centres, or chuck, as required. The lathes are, of course relatively so placed that the load comes where required for each of them. The crane post is usually set over a little out of the vertical, so that when not in use the jib swings inward and cannot be left standing out into the bay, where it might catch passing loads carried by the overhead travellers. These cranes are easily operated by girls.

Fig. 18, Plate LXIII, shows another lifting appliance which has proved of great service in handling the heavier classes of shell. As shown, it is fitted to serve a copper-band press. The crane consists of a simple radial jib made from a joist. The inner end of the jib is carried by the ram of a vertical hydraulic cylinder. Guides and tension rods, which can be seen in the figure, guide and support the jib. The control is by a single valve, which puts the cylinder either to pressure or exhaust and causes the jib to rise or fall. A diaphragm is fitted in the exhaust to prevent too rapid descent. The monkey on the jib has no travelling gear. It is simply pulled along by hand by the operator. Slewing is also done by hand by pulling on the hanging shell or fall. The crane has proved speedy and convenient entirely in the hands of girls.

Our final illustration, Fig. 24, Plate LXIV, merely illustrates a vertical drilling machine of ordinary type. It has been introduced as it is a necessary adjunct to the lathe illustrated in Figs. 8 to 10. When machining the nose end of the shell in this lathe no attempt is made to screw the hole for the reception of the fuse bush. This is done by tapping in a drilling machine as shown in the figure we are referring to. The work could be, and frequently is, done by chasing in an engine lathe, in which, of course, the boring and facing can also be done at the same setting. The advantage of the method we are describing, however, is that, in addition to the simplicity of the lathe used, the tapping is a simple and speedy operation, easily carried out by unskilled labour and giving, with no difficulty, a fuse-bush hole correct to gauge. The amount of scrap made is also very small.

INDUSTRIAL NOTES.

A meeting of the Amalgamated Society of Engineers, attended by Dr. Addison, the Minister of Munitions, was held last Wednesday, at the Central Hall, Westminster. The Minister of Labour, Mr. John Hodge, presided. Dr. Addison stated that it was proposed, where national interests required it, to extend the principle of dilution to particular classes of work, or to the work in particular shops. The intention to do so would be published widely in the newspapers, and three weeks would be allowed for the receipt of any representations by trade unions and for consultation with them and with the employers. Further points dealt with the transference of operatives from one district to another, or from one class of work to another, and Dr. Addison expressed the hope that by the conferences and agreements which were in prospect interruptions of work would not take place. The right to strike on the one hand, or to lock out on the other, would not be prohibited under the new scheme for extended dilution, but he trusted that neither case would occur. Where non-union labour was employed on a class of work in a shop which was performed by union labour before the war, such non-union labour would have to be dispensed with at the end of the war, under heavy penalties if the employer did not satisfactorily meet the case. Amendments were provided for speeding-up arbitration awards; they were to the effect that the tribunal should make arbitration awards, where practicable, within 14 days of the date of reference. It was also decided, under extended dilution, to abolish the leaving certificate system altogether. They proposed also for extended dilution that a workman should be at liberty to give notice in the usual way, but an employer might not take him on private work without the consent of the Ministry of Munitions. He invited the society's delegates, when the leaving certificate system was abolished, to use all their influence to help the Ministry in diminishing as much as possible the migration of labour.

The Minister of Munitions has announced that he has made further orders under the Munitions of War Acts, 1915 and 1916, under which 44 additional establishments have been declared controlled establishments. The total number of these establishments is now 4,942.

We read in *The Birmingham Daily Post* that the metal rolling mills are now working under less pressure than for a long time past. Government requirements are on a reduced scale, but this is probably only a passing fluctuation, due to war exigencies in other directions. Metal rolling for civil trade is, of course, forbidden. Operations are restricted to work which carries the A certificate, or something approximating to it. Government contractors who use rolled metal find no difficulty in getting prompt deliveries against new orders, and this particularly applies to the lower grades of material. Productive capacity has, of course, been greatly increased since the war began, and if, as is supposed, the falling-off of demand is due to temporary causes, it will be possible materially to enlarge the output as soon as fresh requirements develop. It does not appear that any mills are idle or that there has been any reduction in the number of workpeople employed.

Miss Isabel Sloan, assistant secretary of the National Federation of Women Workers, has been appointed to co-operate with Sir George Askwith, Chief Industrial Commissioner, in dealing with labour disputes in which women are affected. Miss Sloan has during the past year played an active part in the negotiations arising out of industrial disputes. Miss Macarthur is secretary of the federation in question.

The Director-General of National Service announced last week that on and after Thursday, the 7th inst., the issue of forms to employers permitting them to engage men (under certain conditions) for work in trades and occupations covered by the Restricted Occupations Order will be made only by the Commissioners and Sub-Commissioners of the National Service Department, and not by the officers of the Employment Exchanges as hitherto. Employers who wish to obtain permits can apply to the Sub-Commissioner for their district, either directly or on forms of application which they may obtain from Employment Exchanges. The name and address of the Sub-Commissioner in any district will be furnished upon application to the National Service Commissioners or the local National Service Committees.

The arrangements under which any man who is enrolled as a National Service Volunteer may be engaged for any occupation, whether covered by the Restricted Occupations Order or not, still remain in force, and the official form of acknowledgment of his offer of service embodies the necessary permit.

The notice gave the names of the Commissioners appointed for the following districts: London and South-East; Northern; Yorkshire and East Midlands; North-West; West Midlands; South-West; Wales and Scotland.

We are informed that the Amalgamated Society of Engineers have written to Mr. John Hodge, Minister of Labour, putting forward a new demand for an increase in their members' wages. They say that in accordance with the agreement arrived at between the Engineering Employers' Federation and the trade unions in the engineering and foundry trade in February last, at a conference held under the presidency of Sir George Askwith, they are making an application for a national advance of wages, on behalf of their journeymen and apprentices, equivalent to 100 per cent. on the wages obtaining in July, 1914, or, in other words, a wages advance of 100 per cent. less the advances granted during the war period by the Committee on Production. Since the commencement of hostilities the engineers' wages have been advanced by about 40 per cent.; the men's present demand would therefore mean a further advance of about 60 per cent. The letter referred to is signed by Mr. J. T. Brownlie, chairman of the Amalgamated Society of Engineers, and by Mr. Robert Young, the secretary.

The Chancellor of the Exchequer announced in the House of Commons last Monday that the Commissioners appointed to investigate labour unrest were:—

North-East Coast: Sir Thomas Munro, chairman; Mr. P. Bright, employers' representative; Mr. H. Davies, employees' representative.

North-West Coast: Judge Parry, Mr. John Smethurst, and Mr. J. R. Clynes, M.P.

Yorkshire and East Midlands: Sir George Croydon Marks, M.P.; Sir Maurice Levy, M.P.; Mr. J. J. Mallon.

West Midlands: Major J. W. Hills, M.P.; Mr. J. W. Wight, Mr. A. G. Cameron.

London and South-East: Judge O'Connor, Mr. Allan H. Smith, Mr. J. Voce.

South-West: Mr. W. W. Mackenzie, K.C.; Sir Alfred Booth, Mr. G. Chambers.

Wales (including Monmouthshire): Mr. Lleufer Thomas; Mr. Thomas Evans, Mr. Vernon Hartshorn.

Scotland: Sheriff T. A. Fyfe; Mr. Noel E. Peck, Mr. J. W. Ogden, J.P.

It was proposed, he added, that the Commission should begin work immediately.

The Prime Minister, supported by the Minister of Labour and the Minister of Munitions, last Tuesday received at Downing-street the Commissioners appointed to investigate the causes of the labour unrest. He thanked them for undertaking a difficult, onerous, and perhaps very thankless task. They would be required to inquire into and to report upon industrial unrest and to make recommendations to the Government at the earliest possible date. In the course of his speech to the Commissioners Mr. Lloyd George stated that the industrial machine had been working at exceptionally high pressure, a pressure quite unknown in times of peace in this or in any other land, in fact a pressure it was never before known that the industrial machine was capable of bearing. Five millions of men and more, in the prime of life, the picked young men of the country, had been withdrawn from industry. It was true that we had about a million women now engaged in industrial pursuits previously followed by men. But still, the pressure was enormous. With diminished numbers in the industrial army, they had in many cases to maintain the output, and in many cases to increase it. Consequently there had been a good deal of overstrain, fatigue and exhaustion, with all the irritation that ensued in cases of that kind, and he had no doubt, owing to the innumerable changes which had to be effected in order to adapt the peace machine to war exigencies, there had been a good deal of friction. They were dealing, first of all, not with hard metal, but with flesh and blood, and he had no doubt that many mistakes had been made; many errors had perhaps been committed on both sides. Such things were almost inevitable when one considered the whole of the conditions under which they had been working during the last two or three years. The marvel was that there had been so few of these difficulties. But the results accomplished had been beyond the anticipations, he might almost say the dreams, of any man. It had undoubtedly been a great surprise to our enemies and a disappointment to them. It had been a great source of joy to our friends and a source of conscious pride to every man who loved his native land to see that Britain, when the pressure came, was capable of giving such a response. In regard to the investigation by the Commissioners, Mr. Lloyd George said that all they wanted to know as a Government was "What are the facts?" They wished the inquiry to be an impartial one, and he felt certain that such would be the case. They wanted to know the real truth about the causes of unrest; unless they knew the real truth they could not take steps for redress.

In the June issue of the Amalgamated Society of Engineers' *Monthly Journal and Reporter*, Mr. Brownlie, the chairman of the society, deals with the recent "unconstitutional and irregular" stoppage of work by the men, particulars of which are given in our former issues. He finds it difficult to state exactly what was the real cause of this unofficial strike, but thinks there can be no doubt but that the Government is not free from responsibility. The arbitrary way, he says, in which the Government departed from the pledges given to the society in the matter of the trade card scheme, and the introduction of a Bill in Parliament to enforce the principle of dilution on private and commercial work, accentuated the feeling of unrest. The unconstitutional strike, he adds, was organised and engineered by the shop stewards, "who avowedly are out to set at defiance constitutional authority." Those who took part in the strike were actively or passively violating the rules of the society. The shop stewards have no constitutional power whatever, and since there appears to be much misapprehension in the minds of many members in regard to the functions of shop stewards, the rule governing them is quoted as follows:

"Rule 13, Clause 5.—District committees may also appoint shop stewards in workshops or departments thereof in their respective districts, such stewards to be under the control of the committee, by whom their duties shall be defined."

Shop stewards in various districts have been arrogating to themselves powers beyond their functions set out in the rule by the taking of votes for and against a strike, which is a flagrant violation of the rule. The only authority in the society than can take a vote in regard to a strike is the district committee, and that body can only do so after it has received the sanction of the executive council. Therefore a vote taken by any other body is illegal, and does not carry with it any of the benefits of the society.

The annual general meeting of the Association of Consulting Engineers was held on May 30, when the chairman, Mr. H. J. Rofe, stated that as British capital would no doubt be largely employed in financing schemes abroad after the war, the committee trusted that British consulting engineers would to a large extent be employed to advise upon them.

He added that the committee had kept in close touch during the year with the Local Government Board and had continued to urge upon them the necessity for undertaking now the preliminary work on the British schemes which were of urgent necessity and which should be put in hand as soon as possible after the war. A register of work which the local authorities have in view had been compiled from the returns called for in a letter issued by the Board last year, and in the case where works were considered by the Board to be of an urgent nature a further communication had been sent out, suggesting that, in order to avoid unnecessary delay when the present restrictions on the execution of works and the raising of loans for the same were withdrawn, particulars of the proposed works should be submitted to the Board as soon as practicable, when they would be considered, inquiries held if necessary, and, if approved, brought to the point when the permission for the raising of the loan only would be necessary to put the work in hand. This placed matters in a much more satisfactory condition, and was, he thought, as far as the Board could be expected to go. The matter now rested with the local authorities to take the initiative. The Board had already in certain cases granted permission for the raising of loans sufficient to cover the fees and expenses incurred in preparing the necessary plans, specifications, schedules of quantities and estimates, and it was hoped that local authorities would take full advantage of this permission, which, there was no reason to doubt, would be extended to similar applications in respect of works of an urgent nature, and particularly works of water supply and sewage disposal.

At a meeting held last Monday of the Cardiff City Council, the Lord Mayor stated that arrangements were being made to establish the shipbuilding industry in Cardiff. He assured the promoters of sympathetic consideration. In the past the Development Committee had discussed the matter, but at that time the difficulties that presented themselves were those of labour and housing. He understood, however, that these matters had now been largely overcome. Councillor Smith stated that something like 1,000 men would be employed, and Councillor Thomas added that local landowners had behaved most generously towards the promoters.

The same journal deals with the metric system, which it approves, and states that if there was anything superlatively clever or exceedingly simple in the British system one could understand the tenacity which clings to the system, but it is neither clever nor simple; it is doubtful whether there is one person in 500 in the British Isles who really understands the whole of the British system of weights and measures or who realises the extent to which this system permits the swindling of the poor and the ignorant. The average man when he reads of a quarter of corn seldom realises that a quarter may be any weight between 312 lb. and 504 lb. according to the character of the grain or the country of its origin. Nor does he know that the so-called pecks of seed potatoes that he is buying are not pecks of 20 lb. but stones of 14 lb. It adds that these examples are only illustrations of the facilities which the system offers to the trader against the people in this country. The foreigner whom we desire to secure as a customer prefers to deal in coins, in weights, and in measures he understands, and consequently starts off with an initial inclination to open trading accounts with Germany, Austria, Hungary, and the other countries who have adopted and do use the common system of weights and measures. To secure his custom this country must meet his needs.

In the issue for the present month of *The Federationist*, Mr. W. A. Appleton, the secretary of the General Federation of Trade Unions, says that the world had long fixed the responsibility for the war and expressed its condemnation of the methods which the Central Powers, under the tutelage of Germany, had adopted towards combatants and non-combatants, and towards the lives and commerce of neutrals. Having fixed the responsibility, the world will also fix the penalty for the lives sacrificed, the countries ravaged, the material resources destroyed, and the debts created. While the possibility of military success remained on her side, Germany proclaimed the aggressor's formula: "The losers pay." With defeat threatening her, she unofficially encouraged through her many agencies the cry of "no indemnities and no annexations . . ." It was obviously impossible to extract from a beaten Germany such indemnities as would restore to those she had outraged the material resources and the treasures they enjoyed prior to August, 1914, but it should be neither impossible nor unjust to exact such terms as would keep her so occupied in making restitution and reparation that she would have no time during the present century to dream of, or prepare for, further military adventures. . . . Let there be no mistake. If Germany wins, she will both annex and extract indemnities. If she decided to give some semblance of value to the contrary protestations of her apologists in this country, she would even now cease her forceful exaction of indemnities in cash and kind from Belgium and Roumania. . . . She was enforcing slavery and passing sentence of death, regardless of Hague Conventions and international understandings, and there was nothing in her past history or her present conduct which justified any hopes of clemency if she secured victory. . . . If due consideration was given to the wishes and needs of the Colonies and India, if it was always remembered that social democracy in Germany had not the power seriously to influence even home policy, allied democracy would insist upon a reasonable contribution towards the fund for restoring what the aggressors had destroyed.

THE PRODUCTION OF TURPENTINE, TAR AND CHARCOAL IN POLAND.

DR. H. HARKORT writes on the subject of producing turpentine, tar and charcoal, in Poland (in *Zeitschrift für angewandte Chemie*, of October 3, 1916). As turpentine has practically never been produced hitherto in Germany, he recommends the adaptation of the Polish method in as far as it applies principally to the production of turpentine. The plant as used in Poland is indicated in Figs. 1 and 2. The apparatus consists of a cylindrical oven with a beehive-like top. The roots of firs (preferably those which have remained in the soil for some time

POLISH OVEN.

Fig. 1.

Section b.d.

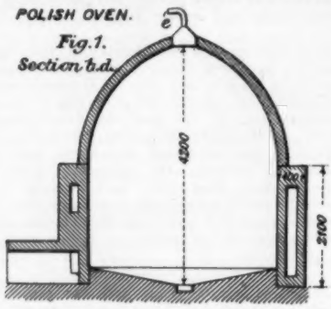
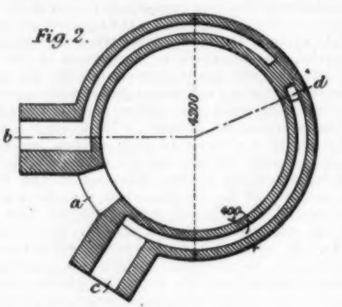


Fig. 2.



RUSSIAN OVEN

Fig. 3.

Section y.y

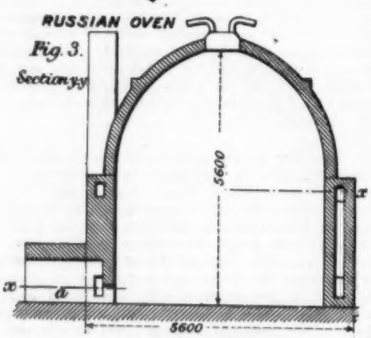
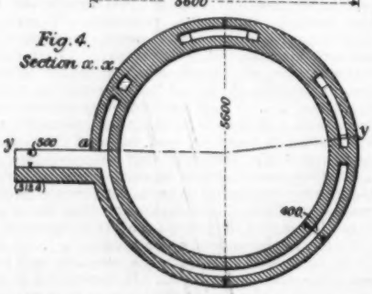


Fig. 4.

Section a..x.



after the trees have been cut down) are charged into the opening *a*, while the furnaces *b* and *c* are fed with wood fuel. The products of combustion enter at *d* into an annular flue, and finally escape through a short chimney located over the feed-door *a*. The base of the oven is of a slightly inverted cone shape, so that the tar, when accumulating, will run to the centre, from whence it can be led away. Soon after the furnace has been started there is an escape of steam and turpentine at *e*, which continues for three days, after which the opening *e* is closed, when the tar begins to run and accumulate at the base. The fires at *b* and *c* are continued until the tar ceases to run off, by which time the charge in the oven is converted into charcoal. In order to obtain the purest turpentine it is necessary to heat up slowly for the first day or two. After keeping up the fires for three days the temperature in the interior rises to over 100 deg. C., consequently the products of distillation escaping at *e* are much adulterated and too dark in colour, the collection at *e* must then cease and the tar be collected instead.

About twenty years ago the Russian oven was introduced (see Figs. 3 and 4), as it yields a better and purer turpentine. This has but one furnace at *a*, from whence the fire gases pass to the right and left in horizontal flues to the opposite side, where they are led into other horizontal flues on a higher level, so that they play round the oven three times in horizontal flues before they escape by the chimney. Or as an alternative the gases are led up and down six times in the circumference before they escape; the latter arrangement of flues is shown in the illustrations. With these ovens the roots of the fir trees remain in the oven only until all the turpentine is collected, while the tar and charcoal are produced in smaller separate ovens, to which the roots are transferred after the turpentine has been extracted. These smaller ovens are about 2 m. in diameter and about 2 m. high, and are also of beehive shape, with an aperture at the top, of 1 m. in diameter, through which they are charged; the roots are then set on fire and the opening is closed by a perforated iron plate. After about 20 hours of slow carbonising the opening is entirely closed by a solid iron plate; the fire then dies down for want of oxygen. The process is but a crude one, and extravagant in fuel, but the fir forests in which turpentine is made yield, as a rule, abundant fuel. Large Russian ovens will yield about 110,000 kg. of turpentine per annum.

THE WINDOW-GLASS MACHINE.*

By ROBERT LINTON.

THERE are two kinds of transparent sheet glass, termed commercially plate glass and window glass, manufactured by two radically different operations. In making the former a quantity of molten glass is poured upon a casting table and rolled out in a sheet, which is placed in a kiln, where it is annealed and cooled. The sheet produced in this way is rough, as the metal table and roller, no matter how smooth, will leave an impression on the soft glass, consequently it has to be ground down to a plane surface on both sides and then polished in order to render the surface smooth and the sheet transparent. Window glass is made by blowing or drawing a cylinder in such manner that nothing but air comes in contact with the surfaces during the operation, cutting open the cylinder longitudinally, reheating it, and flattening it out in a sheet, which is then annealed.

Glass blowing is an art that runs back into antiquity—no one knows how far. A book on glass-making published in Leipsic in 1689 that I have in my library contains an interesting illustration of glass-blowers at work in a factory of that period. A writer as long ago as the eleventh century has described in considerable detail the blowing of glass cylinders and their subsequent flattening into sheets, and there seems to be little doubt that cylinders were blown long before that time.

Prior to 1903 window-glass was made entirely by hand, and there is still about 40 per cent. of the production of this country manufactured by this method. A brief description may therefore be of interest and aid in making clear the difficulties involved in devising apparatus to do the work mechanically.

The tool used is the blower's pipe, about 5 ft. long, with a mouthpiece on one end, and on the other the bell-shaped wrought-iron "pipe head." The workmen are the blower, gatherer and snapper, or blower's helper, the three men constituting a "shop." The gatherer starts the operation by dipping the glass, which adheres and forms a small ball. He blows through the pipe head, which has been previously heated, into the molten mass sufficiently to expel the soft glass from the interior and form a small bubble in the ball. The glass is then cooled to the proper stiffness, more glass gathered, and the operation repeated until there is sufficient glass to yield a cylinder of the desired size. For an ordinary cylinder the gatherer usually gathers five times.

The lump, which is in a state of rather stiff plasticity, is then carried to the "blower's block," an iron mould set in water to keep it from becoming too hot, and lined with charcoal to prevent the glass from being marked by contact with the iron. By turning the ball in the block, blowing air into the lump through the pipe and drawing it up towards him, the blower so manipulates the operation as to form a pear-shaped ball, the upper part of which has the diameter and thickness of the cylinder to be produced, the bottom containing a thick mass of glass that has now become quite stiff. The ball is now reheated in a "blow furnace," and when soft enough the blower swings it out in a "swing hole" alongside the blow furnace. The weight of the glass elongates the cylinder, and the blower keeps it distended to proper diameter by intermittently blowing air into it through the pipe. The reheating and swinging out are repeated until the glass in the closed end of the cylinder is of the same thickness as the other parts. This closed end is now exposed to the heat of the blow furnace, the workman at the same time blowing into the pipe and keeping the air confined by holding his thumb over the mouthpiece. The glass in the end softens, and the heat at the same time expands the air in the cylinder, which finally bursts out through the end. The open end is heated still further and swung out into the swing hole in such manner as to make it cylindrical to the end. The pipe is removed by touching a cold iron to the glass just below the pipe head, and the pear-shaped cap removed by stretching a thread of hot glass around the cylinder, allowing it to remain until a heated streak is formed, and touching this streak with a cold iron causes the cap to snap off. The cylinder is split by passing a hot iron back and forth through the cylinder to produce a similar line of heat and touching it at one end with a cold iron, which results in a straight crack from end to end.

The cracked open cylinder is then carried to a flattening oven. It is laid on an iron carriage and pushed into the oven, where it is heated, lifted with an iron tool from the carriage and laid on the flattening stone—a large flat fireclay tile with a carefully levelled and highly polished surface. As the glass softens the cylinder is spread out and then rubbed down flat with a wooden block mounted on a light steel bar. The stone with the sheet lying on it is then moved out of the flattening compartment into a cooler one, the sheet is gradually cooled down, and when it is sufficiently hardened it is lifted by means of a fork with smooth steel tines and laid on a conveyor, which carries it slowly out of the oven. This part of the oven, called the "lehr," is for the purpose of annealing the glass by cooling it slowly and gradually, for otherwise it would be too brittle for commercial use. The ordinary type of flattening oven has four flattening stones set on a circular table—the "wheel"—which is carried on a vertical shaft turned by hand from a bevel gear drive.

It will be readily appreciated that blowing window glass requires unusual judgment and manual skill, as well as more than ordinary physical strength and endurance; also that the size and thickness of sheets that can be produced by hand is quite limited. In single strength ($\frac{1}{8}$ in. thick) the limit is about 14 in. diameter by 60 in. long; in double strength ($\frac{1}{4}$ in. thick) about 19 in. diameter by 70 in. long. The workers were extremely well paid. Blowers' wages ordinarily varied from about 150 dols. to 250 dols. per four weeks, and gatherers' from about 110 dols. to 150 dols. Blowers who made the largest sizes were paid much more than this; I remember one "big blower" in a factory with which I was connected who earned 642 dols. in four weeks.

Window glass is a mixture of silicates of lime and soda. The raw materials are silica sand, limestone and salt cake (sulphate of soda) or soda ash (carbonate of soda). The mixture of these raw materials is called the "batch."

A characteristic analysis of window glass is as follows:—

	Per Cent.
SiO_2	72.50
CaO	12.60
Na_2O	13.67
MgO	0.22
Al_2O_3 Fe_2O_3	1.01
Specific gravity	2.52

Regenerative tank furnaces are now almost universally employed for window-glass melting. A tank furnace consists of a long rectangular hearth or "tank" constructed of massive fireclay blocks and kept filled with molten glass. The firing is through ports in side walls above the blocks, the flame sweeping across between the glass level and the crown from the end where the batch is filled in to a point usually slightly more than half-way to the working end. The batch floats on the surface of the glass bath, exposed to the heat of the fire above and the molten glass below, and is gradually melted, refined and cooled to proper consistency as it is drawn down by the continuous working out of the glass at the other end. The temperature of the melting end is about 2,600 deg. F., and at the working end about 2,150 deg. to 2,250 deg. F. in machine plants.

Glass does not have a definite melting-point in the sense of a fixed temperature at which it passes from a solid to a liquid state. Strips of window glass under test have showed a slight deflection at 840 deg. F., while they lost stiffness at 920 deg. and bent freely at 980 deg. The glass becomes softer as more heat is applied, and becomes entirely liquid, so as to assume readily the shape of a vessel into which it is poured, at about 1,700 deg. With the application of still more heat the glass becomes, of course, more and more fluid, until finally a point is reached where a slight decomposition and loss of alkali takes place, which manifests itself by bubbles of gas rising through the heated mass.

The viscosity of molten glass necessarily varies with the temperature, this being a natural law of liquids. Cohesion is strong, but weaker than force of adhesion to heated substances such as iron or clay. This gradual increase of viscosity with drop of temperature is an important factor in the manufacture of glass by blowing or drawing. The cooler the glass, the stronger is the cohesion of the molecules, and the greater will be the force required to draw the mass out, until at last the glass may become so stiff that the cylinder being drawn will not retain its form and becomes distorted and shapeless.

Liquid glass has a high surface tension at the temperature at which it is worked. In machine operations the glass is supplied to the pot or forehearth from which the cylinder is drawn hotter and therefore more fluid than is suitable for working. To bring it to the proper consistency it is cooled by radiation and convection, either simply by exposure to the air, or by using a water-chilled ring. The radiation of heat from the surface is much more rapid than the conduction of heat through the glass, and the result is a gradual cooling from the surface down, and a mass of glass with gradually decreasing viscosity from the surface down. In drawing a cylinder from such a bath of glass, the portion outside the cylinder has a greater surface tension than the portion inside, as it is slightly cooler.

The important temperatures in window-glass manufacture are the working temperature of the glass—about 1,500 deg. in hand blowing and 1,750 deg. in machine blowing—and the "setting temperature," or the temperature at which glass retains its form, which is about 850 deg. In the liquid state in which glass is worked in machine operations it is so soft as to be extremely sensitive to changes in temperature or variations in

* Paper read before the Engineer Society of Western Pennsylvania.

exterior or interior pressure exerted at the point of draw. When glass is cooled rapidly from the liquid or plastic state to the setting-point, cooling strains develop between the surfaces and the interior of the walls of the cylinder. This is because glass in the solid state is extremely hard and non-compressible. In cooling, the surfaces harden first and the soft mass in the interior readily adjusts itself to their contraction; then the interior hardens, but as there can now be no further yielding of the hardened surface layers, the molecules are left in a condition of tension, and the more rapid the cooling, the higher the tension developed. This condition facilitates the capping-

FIG. 1. SWING HOLES.

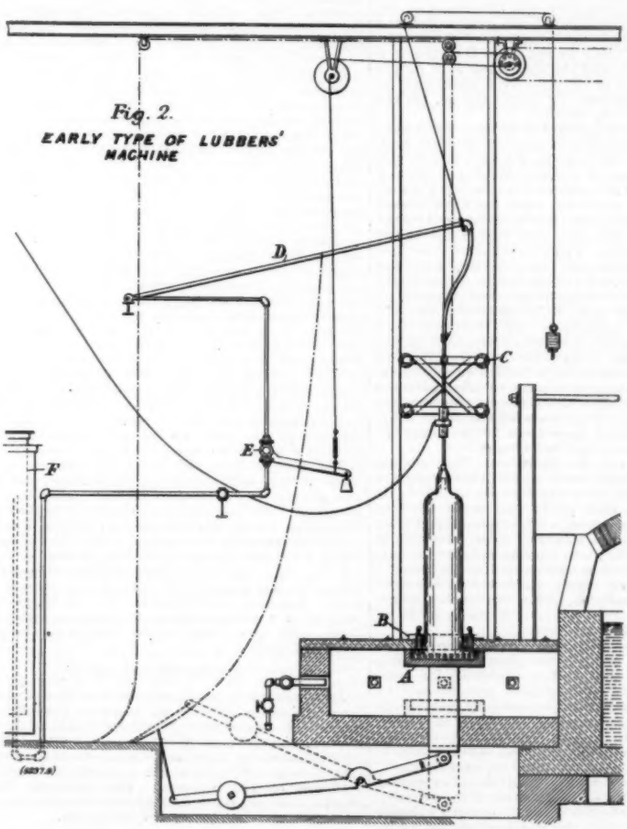


Fig. 2.
EARLY TYPE OF LUBBERS' MACHINE

off and cracking open of the cylinders; it is to remove the strains and reduce the brittleness that glass is annealed.

Somewhere around 1896 John H. Lubbers, a window-glass flattener by trade, began experimenting with a machine to make glass cylinders. He was a man of unusual natural ability, and in working at his trade he had acquired a general practical knowledge of the physical properties of glass to which reference has been made above. He believed that he had devised a practicable method of drawing glass cylinders from a bath of molten glass, but being of limited means and realising that considerable money would be required for his experiments, he disclosed his proposed method to Mr. James A. Chambers, president of the Chambers Glass Company, in whose factory Lubbers was working, and one of the very ablest window-glass manufacturers in this country. Mr. Chambers was much impressed with the practicability of Lubbers' proposed method, crude though the details must have been at that time, and advanced the necessary money to cover the cost of some preliminary experiments. Later a small company was formed, headed by Mr. Chambers, for the purpose of carrying out these experiments on a more extensive scale, for while Lubbers was actually making window-glass cylinders, there were a great many difficulties still to be overcome in order to render his apparatus suitable for the manufacture of window glass in a commercial way. As a matter of fact it required years of work and an enormous amount of money to develop the apparatus to the point where it was finally operated at a profit. Nevertheless the machine of to-day still retains the basic features of Lubbers' inventions, and considering how completely they revolutionised the established processes of window-glass manufacture, Lubbers' ideas, as set forth in his various patents, show a surprising knowledge of the essential conditions for making glass cylinders by machinery.

The experiments were conducted in a small plant located in Allegheny, and it was here that the machine was operated that is shown in Fig. 2. There seems to be no doubt that this was the first machine that was ever successfully employed to make window-glass cylinders.

The Lubbers process is a process for drawing cylinders vertically from a bath of molten glass. This in itself was not a new idea, as several patents—one dating back as far as 1854—proposed this. Lubbers, however, was the first to devise a workable method for really doing it, a process that took into account the peculiar conditions involved in working molten glass, and apparatus that actually made glass cylinders—cylinders that were in every respect similar to those that were blown by hand.

In the drawing A is a flat-bottomed, circular pot placed in a heated kiln and movable vertically as shown by the dotted lines; B is a circular water-cooled shield;

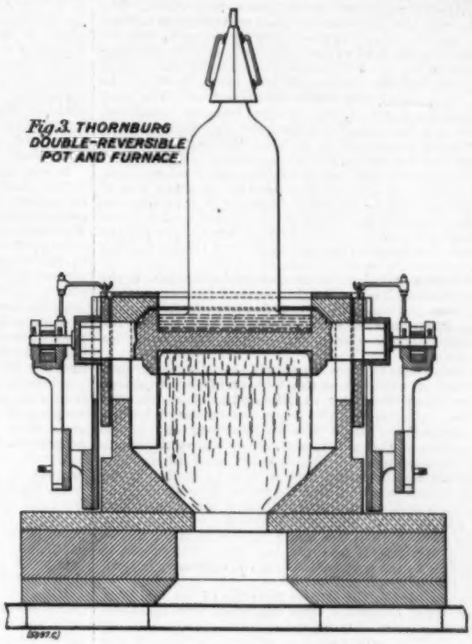


Fig. 3. THORNBURG DOUBLE-REVERSIBLE POT AND FURNACE.

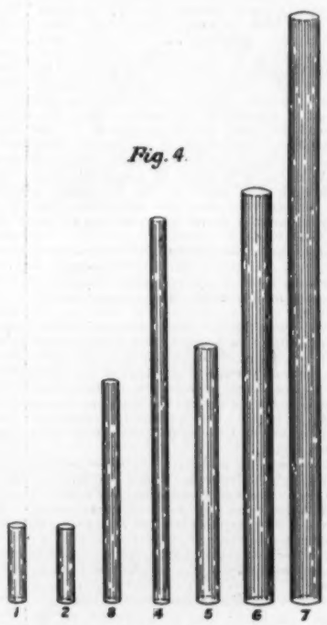


Fig. 4.

C is a crosshead travelling on guides, raised by means of a cable winding on a cylindrical drum and carrying a detachable blowpipe of the general type used in hand blowing; D is a supply pipe for the admission of air under sufficient pressure to keep the cylinder distended to proper diameter; E is a graduating valve which is automatically opened as the cross-head C is raised, the valve being provided with a slotted opening of proper size and shape to admit the requisite quantity of air at each point of draw; F is a gasometer serving to maintain a constant pressure in the supply line conveying air to the graduating valve.

The operation was as follows: The pot A was raised to the top of the kiln and the water shield placed in the position shown. A quantity of glass sufficient for drawing

one cylinder was ladled into the pot. A ball of glass was gathered on a blowpipe, the small bubble blown out as described above in connection with hand blowing, and the ball "marvered," or rolled on a smooth iron plate, so as to thin the bottom portion beneath the bell-shaped end of the pipe; the pipe was hung on the crosshead and lowered into the glass. The crosshead was then raised, air being admitted by the operation of the graduating valve, which swelled out the glass to the diameter of the cylinder to be drawn. The upward movement was then continued until the cylinder reached the desired length, the introduction of air being automatically regulated by the graduating valve. The cylinder was severed from the glass remaining in the pot in any one of several ways—either by dropping the pot and allowing the heat to melt the lower end, by shearing off, or by shutting off the air and continuing the upward movement, which contracted the lower end of the cylinder to a small cord which was sheared off. The pipe, with cylinder attached, was removed from the crosshead, lowered to a horizontal position, the pipe removed and the cylinder capped off as in hand-blowing operations. The pot was lowered to the kiln to reheat it and melt to proper consistency the residue of glass that remained in it.

The control of the machine by the operator was at that time limited to stopping, starting or reversing the drum on which the cable wound that raised and lowered the crosshead, and in manipulating a hand valve on the air supply line between the gasometer and the graduating valve.

Cylinders were also drawn from a forehearth in the melting furnace itself. By this method the necessity of ladling was obviated, the glass flowing directly into a portion of the furnace where it was sheltered from the heat sufficiently to give it the proper consistency for drawing.

The experiments were continued at Allegheny until the spring of 1902, when the factory of the American Window Glass Company at Alexandria, Indiana, was leased to Lubbers, and the work was transferred there from Allegheny. There was a 54-blower continuous tank furnace at this plant, with all accessory flattening and other equipment for this capacity, and the machine installation was designed with a view to testing it out on a practical working scale, and to developing it as rapidly as possible to the point where it could be utilised in the plants of the American Window Glass Company. Material advancement was made, especially in the way of designing mechanical features, but the development of the machine to the point of making the necessary output, quality and cost was still far off.

However, nine of the largest factories of the American Window Glass Company were equipped with machines the following year. The company had been experiencing a serious and constantly growing shortage of blowers, due to the fact that there was a limited number of these skilled men in the country and because the plant capacity of the country had been rapidly expanding. Many independent companies, operating at a low fuel cost, offered high guarantees in wages to good blowers, and many blowers had organised co-operative companies. So that very strong reasons existed for pushing as rapidly as possible the development of the machine process, and it no doubt seemed reasonable to assume that this development would be very much hastened if the machines were installed in these plants, manned as they were with the most efficient operating organisations of the company. With such a force of practical glass makers giving thought and effort to the problems, it would naturally be expected that the difficulties that stood in the way of success would be overcome in the shortest possible time.

As a matter of fact, however, they proved more serious than was appreciated, and the work of developing and improving the various parts of the apparatus continued for about two years longer before satisfactory results began to be obtained.

The record of the work done in these years of experimenting and development is a most interesting story, but it would be beyond the scope of this paper to give more than a very general account of it. Out of the crude apparatus shown in Fig. 2 was perfected a machine that is producing to-day results far beyond the most optimistic expectations of its inventor. One by one the causes of the troubles were located and the apparatus modified or adjusted to correct them.

That this work was so slow and so difficult was largely due to two facts which have been mentioned above, viz.: First, that in the liquid state in which glass is worked in machine operations it is so soft as to be extremely sensitive to changes in temperature or variations in exterior or interior pressure exerted at the point of draw; and, second, that in working glass, cooling strains develop as the glass passes from the liquid to the solid state, causing brittleness.

The work may be divided into five general heads:—

1. Adjusting the character and temperature of the glass bath to the requirements of drawing operations.
2. Increasing the size of the cylinders.
3. Closer regulation of the air supplied to the interior of the cylinder.
4. Better regulation of the drawing speed.
5. Handling the cylinder after completing the draw.

Adjusting the Character and Temperature of the Glass Bath to the Requirements of Drawing Operations.—The method of reheating the residue remaining in the pot after drawing a cylinder and then ladling fresh glass into the pot was not very satisfactory. It was difficult to get good quality of glass, for unless the glass in the pot and that which was ladled into it were heated to the same temperature and brought to a very fluid condition, they would not mix properly, and thus produced streaks in the cylinder. Similar difficulty was experienced in melting back the residues in the forehearth; if the glass was heated hot enough and skimmed when necessary in the manner employed in skimming the gatherers' rings in hand operation, the quality was satisfactory, but the operation was very slow.

It was then proposed to drain the pot between draws, and to accomplish this a furnace was built with four pots mounted on a turntable and so arranged that each pot would be tilted at a certain point. In this way there would always be one pot used for drawing cylinders while the others would be heating and draining. An improvement on this apparatus was the double reversible pot mounted on trunnions shown in Fig. 3 (invented by L. A. Thornburg), in using which one side was always being drained while a cylinder was being drawn from the glass in the other. When the Gas City plant was equipped it was necessary to decide which of the three forms of apparatus would be adopted, and the Thornburg reversible pot was chosen as being best suited to the operations as they were conducted at that time. It is still used by the American Window Glass Company, and it is doubtful if any other form of receptacle for the molten glass can equal it for high output and economical operation.

It was also discovered that there was gradual cooling of the glass during the draw, and that it was important to control this so as to prevent one side from cooling more rapidly than the other as far as could be done. The effect of inequalities in the temperature of the bath is to produce "thick and thin" glass, *i.e.*, that portion of the circumference of the cylinder where the glass is coolest at the point of draw will always be the thickest; also in many cases this inequality in temperature causes the cylinder to travel towards one side of the pot instead of continuing to draw vertically from the starting position. A great deal of difficulty was experienced in eliminating this "thick and thin" glass, as it could be due to a number of causes. More positive adjustment of the machinery, an improved type of ladle and method of lading the glass from the tanks to the pots, more care in keeping the pots uniformly heated, and shielding the glass bath from draughts, very greatly reduced the proportion of "thick and thin" glass produced. It was however, found so difficult to maintain absolute uniformity in the temperature and rate of cooling of the bath, that the practice was finally adopted of drawing from the centre of average viscosity, instead of from the centre of the pot. In other words, when the glass in a place is thick and thin, and the apparatus is in proper condition, the blowpipe is simply moved sufficiently to bring the thickness uniform, or practically so, for the entire circumference of the cylinder.

It was thought in the early days of machine operations that some change in the chemical composition of the glass, or in the character of the materials from which it was made, would be necessary in order to adapt it to the new working conditions. The cylinder was now being drawn from glass in a liquid condition, while the hand blower manipulated a lump sufficiently stiff to be retained on the end of the blowpipe. The glass was worked out of the tank much more rapidly, which accelerated the flow proportionately. Considerable experimenting was done with various mixtures and various kinds of materials, but in the end it was found that the chemical composition that gave the best glass under hand operations was also the best for machine operations. The increased draw on the tanks necessitated, however, alterations in the melting furnaces, and the tanks of the American Window Glass Company so remodelled have yielded quite remarkable results. The maximum amount of glass gathered in 24 hours from one of these under hand operations was 3.7 per cent. of the total contents of the tank, while under machine operations more than 20 per cent. has been ladled from the same tank in 24 hours.

Increasing the Size of the Cylinders.—The original Lubbers machine, as has been stated above, made a cylinder about the size of a hand-blown cylinder. It soon became obvious that production could be very materially increased by ladling a larger quantity of glass into the pot and drawing a longer cylinder, which could be cut up, after lowering, into lengths suitable for flattening. This introduced complications in the control of drawing speed and air supply which will be discussed farther on, but eventually the point was reached where five flattening lengths about 14 in. in diameter by 60 in. long could be produced at one draw.

The cylinders were at first capped off and severed into flattening lengths by using a hot glass thread; this, however, proved too slow and cumbersome for commercial operations, and an appliance was devised by which the heated streak was produced by passing an electric current through a resistance wire held in contact with the cylinder. After a long period of experimental work this method was finally adapted satisfactorily to the operation, and has been in general use ever since.

The next step—and a most important one in increasing production—was to increase the diameter of the cylinder. It was not possible to flatten a single-strength cylinder that was much larger than the standard size of 14 in. in diameter by 60 in. long. It was suggested, however, that there would not be any difficulty in flattening if the dimensions would be reversed, and flattening lengths produced which would be 19 in. in diameter by 42 in. long, employing, of course, pots of larger diameter and containing a larger quantity of glass. This method was tried out, and proved so successful that it was immediately adopted in all the factories operating machines. The size of the cylinders has since then been considerably increased, so that to-day, using a 36-in. pot, single-strength cylinders are made up to 21 in. diameter by 460 in. long, and double-strength up to 24 in. diameter by 320 in. long. Fig. 4 shows the steps in the development of the size of the cylinder from that made from Lubbers' first machine to that made at present.

(To be continued.)

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

South Yorkshire Coal Trade.—Greater activity prevails in the market, and all round there is a firm tone. The demand for best steam hards is one of the heaviest on record so far as the home consumers are concerned, and if it were not for the fact that the export trade is of smaller dimensions than heretofore the tightness would be gravely accentuated. Munition works, railways, and other industrial undertakings are bidding for the fullest possible deliveries, and there is hardly anything to be had outside contract accounts. Pits have no reserves to draw upon, and their daily output goes away automatically. Smaller steam sorts continue in big request, and steam nuts do not equal the inquiries, whilst cobbles find a ready sale. Slacks of the smaller, as well as the larger, grades are disposed of without difficulty. Cokes of all qualities are strong at full values. The chief characteristic of the house coal market is still the demand for stocking purposes. This almost wholly affects the better sorts, and there is a small surplus of an inferior grade for conversion to industrial requirements. Quotations:—Best branch hand-picked, 20*s.* 6*d.* to 21*s.* 6*d.*; Barnsley best Silkstone, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire best brights, 18*s.* 6*d.* to 19*s.* 6*d.*; Derbyshire house coal, 17*s.* to 18*s.*; best large nuts, 16*s.* 6*d.* to 17*s.* 6*d.*; small nuts, 15*s.* 6*d.* to 16*s.* 6*d.*; Yorkshire hards, 16*s.* 6*d.* to 17*s.* 6*d.*; Derbyshire hards, 16*s.* to 17*s.*; best slacks, 12*s.* to 13*s.*; seconds, 10*s.* 6*d.* to 11*s.* 6*d.*; and smalls, 7*s.* 6*d.* to 8*s.* 6*d.*, per ton at the pit.

Iron and Steel.—The expected has happened in the raw material market, and there is accordingly some criticism of the authorities. As readers of these notes will be aware, there have for some time been developments in the output of basic pig-iron at the expense of foundry sorts, and now there are distinct indications in the market that the improved production of the basic kind has led to a scarcity in foundry iron which will necessitate immediate remedying. Forge iron is still arriving in sufficiently large tonnage to meet all local demands, and the supply of hematite is quite satisfactory. Not all the imports of Swedish material have been stopped, and there is proof that some considerable tonnage has come into the market recently, for there is an easier tone in this area. Swedish bar iron is in good demand on the part of steel makers, and high prices are being willingly paid for early deliveries. There is also a ready inquiry for shell discard steel, steel-melting scrap, and wrought-iron scrap. A big scheme, which has been on hand for some time, has now matured, and resulted in the commencement of new steel furnaces. These are expected to have a permanent influence in increasing the output of steel and not to be merely a war-time innovation. The latest prices for steel billets are as follow:—Bessemer acid, 14*l.* 10*s.*; Siemens acid, 15*l.* 10*s.*; hard basic, 11*l.*; and soft basic, 11*l.* South Yorkshire Crown bars are nearly 14*l.* net. Crowbars for the War Office are amongst recently placed orders, whilst files and saws for war work and army purposes are wanted in greater numbers. Agricultural engineers are still working at the maximum pressure, and confidently anticipate that they will be able to produce all the machinery required for the harvest season. Orders are on a big scale, whilst repair work is no mean item. Sheep shears for export represent another active branch, for the demand has increased in proportion to the inability of the machine shear makers to set aside certain war work to fulfil orders. Cutlery firms, having survived the threatened shortage of material in a more or less satisfactory way, have now another menace to face in the form of a labour shortage. They have none too many skilled men as it is, but there are distinct signs that many of these will have to go. It is feared that all men who are not on Government contracts may have to join the army. The irony of it is to be found in the fact that "domestic" trade was never so easy to obtain, and never so remunerative as it is to-day. Plate and silversmiths report a notable revival in overseas orders, and licences for this class can be obtained without difficulty. The general export trade of the city is maintaining a high level. Amongst recent indents are to be found those for tools of all varieties, sickles, sheep shears, springs, plane irons, vices, files, saws, knives, hardware, filters, steel, plate and cutlery.

INCREASE OF CAPITAL IN GERMAN CONCERNS.—The large Augsburg-Nüremberg Machine Company is increasing its capital from 27,000,000 marks to 36,000,000 marks, at an exchange of 125 per cent., and the Hermann Poege Electricity Company, Chemnitz, is increasing its capital from 4,500,000 marks to 6,000,000 marks at an exchange of 130 per cent. The Rhenania Chemical Works, Aachen, have decided to increase their capital from 6,000,000 marks to 9,000,000 marks.

THE DUTY ON IRON IN AUSTRIA.—The Austrian Government has recently been petitioned to reduce the high duty on iron goods in Austria-Hungary. The duty on raw and half-finished goods, reckoned according to German peace values in 1912, amounts, respectively, to 36 per cent. and 66 per cent. Including the freight, the Austrian iron works in these branches enjoy a protection of from 50 per cent. to 80 per cent. Of the 2,000 concerns engaged in the iron industry only 120 have their own foundries, whilst the 1,880 concerns are obliged to buy their requirements of iron castings. As an example, bar iron is mentioned; this cost, in the year 1913, in Germany, 13.20 Austrian kronen. The duty in Austria is 6.50 kronen and the freight 1.50 krone, a protection of 8 kronen, or 60 per cent. A reduction of all the duties in question is strongly urged.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scotch Steel Trade.—While the industrial situation in the West of Scotland remains unchanged there is no doubt that the dominating factor in the steel trade is the abnormally heavy and continued demands of Government. Certainly, increased milling facilities have greatly added to the output, but even this is as rapidly absorbed as was the smaller tonnage of the earlier months of the war, and still the bulk of the output is required, directly or indirectly, for the prosecution of hostilities both on the western and on the eastern front. Recent events show that the high pressure which has been such a prominent feature in the steel-making trade for so many months past must be maintained, and every endeavour made to fulfil all contracts with the least possible delay, although makers have many difficulties to overcome. General business would be good were it possible for ordinary mercantile orders to be undertaken, but the demand continues much in excess of any available supply. No change has taken place so far as export is concerned, while the requirements of the shipbuilders are steadily on the increase.

Malleable Iron Trade.—There is little or nothing to chronicle in connection with the malleable iron trade, beyond heavy books and a constant demand, particularly on Government account, the production of both the iron and steel departments being greatly in request. Indeed these requirements have increased so much that it is quite impossible for makers to consider the claims of any overseas customers whatever, especially since the further restrictions on the export of iron have come into operation.

Scotch Pig-Iron Trade.—As in all other branches of industry engaged on war work, ceaseless activity prevails in the pig-iron trade, and the task of supplying the requirements of Government is no easy one. All grades are in constant request, the local steel works rapidly absorbing every available ton of hematite, and the iron works as much of the foundry qualities as it is possible to obtain. There is still some scarcity of No. 1 foundry grade, which is scarcely to be wondered at considering the existing conditions of demand. Firm prices rule, being well maintained at maximum levels.

Glasgow Fair Holidays.—The announcement that the Glasgow Fair holidays are to take place as usual in the middle of July has been received with much satisfaction, the industrial population having a lively recollection of the muddle made last year through official intervention. Without doubt the Clyde workers have given a good account of themselves during the past twelvemonth, and well deserve some reasonable consideration. It has been intimated that the Board of Trade favours special facilities for travelling by rail, and it is further expected that the Shipping Controller will come into line with this, as none knows better than Sir Joseph Maclay how greatly the workers appreciate the services of the river sailing fleet, nor how very much this has been missed. Although the holiday will be general, Government, or, more correctly speaking, the Ministry of Munitions, reserves to itself the right to decree that no cessation of labour may take place in any controlled establishment where special and urgently required work is in progress.

Clyde Wages.—Two wage awards of special interest to West of Scotland workers have just been issued by one of the two divisions of the Government Committee on Production, the members of which are Sir George S. Gibb, Mr. John M. Denny, and Mr. George J. Rowe. This consists of a 5 per cent. advance to the steel-workers represented on the Board of Conciliation for the Steel Trade in the West of Scotland, and an advance of 3*s.* per week to the members of the Amalgamated Society of Steel and Iron Workers employed by Messrs. Stewarts and Lloyds in the Clydeside Works, Tollcross. It has been arranged that these advances shall take effect "as from the beginning of the first full pay following the date of the award," both advances to be regarded primarily as war wages necessitated by and dependent upon the present abnormal conditions of labour.

THE EVOLUTION OF THE TANKS.—We have received the following communication from the special Intelligence Branch of the Ministry of Munitions of War:—"Major Walter G. Wilson, who has received the honour of a Companionship in the Order of St. Michael and St. George, is the officer who, with Sir William Tritton, worked out the mechanical design of the first of the now famous 'Tanks,' for the Admiralty Committee of which Sir Eustace Tennyson D'Eyncourt was chairman. Major Wilson's name was included in the list published in the *Gazette* of the 4th inst., and his honour has been given in respect of the work he did on the 'Tanks.' Sir William Tritton received the honour of knighthood in January last."

THE STANDARD SPECIFICATION OF THE NORTH-EAST COAST ENGINEERS AND SHIPBUILDERS.—It will be remembered that some time ago the council of the North-East Coast Institution of Engineers and Shipbuilders drew up a specification for cargo ship engines, which was very carefully considered and slightly modified to meet suggestions made. We are glad to learn that a beginning has been made in the acceptance of this standard specification by shipowners, Messrs. Furness, Withy and Co., Limited, having contracted with Messrs. Irvine and Co., of West Hartlepool, for a large cargo carrier, the machinery for which is to be supplied by Messrs. Richardsons, Westgarth and Co., Limited, and is to embody the requirements of the standard specification of the North-East Coast Institution.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—The Cleveland pig-iron market is steady and firm. Business, however, is rather quieter, the June allocations for the home foundries and for customers in Scotland having all been put through, and deliveries are proceeding smoothly. There is no dearth of iron. Owing to the very satisfactory working of the furnaces just now, there is a rather larger output of the higher qualities of pig-iron. Forge iron is still very plentiful, notwithstanding that it is being taken up freely for use here and in Scotland. Producers have rather considerable stocks, and would doubtless entertain offers somewhat below the recognised market quotation. There is a large demand for Cleveland pig-iron for abroad, but export business is dominated by the tonnage situation. Shipments, however, show some improvement. For home consumption No. 3 Cleveland pig-iron, No. 4 foundry, and No. 4 forge are all quoted 92*s.* 6*d.*, and No. 1 is 96*s.* 6*d.*; whilst for shipment to France and to Italy No. 3 is 102*s.*, 6*d.* No. 4 foundry 101*s.* 6*d.*, No. 4 forge 100*s.* 6*d.*, and No. 1 107*s.* 6*d.*

Hematite Iron.—There is much stringency in the supply of East Coast hematite iron, but in this branch also output is sufficient to meet current requirements of home consumers and to have some small surplus for despatch to our Allies. Consumers, of course, are not able to accumulate any stock for future needs, but their immediate wants are fulfilled, and the increased production on the West Coast should have a tendency to ease the situation here. The business passing is mostly confined to home transactions, sellers still showing reluctance to book foreign orders on the terms named. Nos. 1, 2 and 3 are 122*s.* 6*d.* for home use, 137*s.* 6*d.* for shipment to France, and 142*s.* 6*d.* for export to Italy.

Coke.—Coke continues in very good request for local consumption and values are fully maintained, notwithstanding plentiful supply. Medium blast-furnace kinds keep at the fixed maximum of 28*s.* at the ovens, and the limitation price of 30*s.* 6*d.* at the ovens is still named for low phosphorus qualities.

Output of Ironstone.—Cleveland ironstone mineowners and miners continue their effort to assist the Government to increase the output of ironstone, and with that object are to hold a further joint meeting next week. By arrangements with the Ministry of Munitions numbers of Cleveland miners are being released from the army, and it is estimated that some 400 have returned to Cleveland.

Manufactured Iron and Steel.—Nothing new of moment is ascertainable concerning the various branches of the finished iron and steel industries. Manufacturers are working at full pressure, and the huge output is absorbed by Government requirements and the needs of the shipyards. Quotations, all round, are stiff. The following are among the principal market rates to home customers: Common iron bars, 13*l.* 15*s.*; best bars, 14*l.* 2*s.* 6*d.*; double best bars, 14*l.* 10*s.*; treble best bars, 14*l.* 17*s.* 6*d.*; iron ship plates, 13*l.* 10*s.* to 14*l.* 10*s.*; iron ship angles, 13*l.* 15*s.*; iron ship rivets, 18*l.*; packing iron and steel (parallel), 13*l.*; packing iron and steel (tapered), 15*l.* 5*s.*; steel bars (no test), 14*l.* 10*s.*; steel ship plates, 11*l.* 10*s.*; steel ship angles, 11*l.* 2*s.* 6*d.*; steel ship rivets, 20*l.* and upward; steel boiler plates, 12*l.* 10*s.*; steel joists, 11*l.* 2*s.* 6*d.*; steel strip, 17*l.*; steel hoops, 17*l.* 10*s.*; and heavy sections of steel rails, 10*l.* 17*s.* 6*d.*

Blast-furnacemen's Wages.—An amicable settlement has been effected in regard to the demand of the Cleveland and Durham blast-furnacemen for an advance in the war bonus. The ironmasters had made an offer which the men rejected as inadequate, and after two abortive meetings at Middlesbrough the Blast-furnacemen's Association laid the whole of the facts before the Ministry of Munitions, with the result that a conference has been held in London at the Ministry of Munitions between representatives of the ironmasters and the blast-furnacemen in the presence of representatives of the Ministry, the outcome of which is that additional bonuses of 9*d.*, 8*d.*, 7*d.* and 6*d.*, graded according to base rates, have been agreed to. The lower base rates receive the higher amounts. The arrangement is retrospective as from April 1.

Wages at Consett.—Officials of the National Amalgamated Union of Labour have, for the past eight months, been negotiating with the Consett Iron Company, Limited, on behalf of the men in the firm's employ who are members of the union, for an increase of wages, to bring the rate to what is paid at other places. In some instances wages have been brought up to the standard, while in others advances have been secured. The men engaged on the light mill shears have been granted concessions equal to between 1,000*l.* and 2,000*l.* a year additional wages.

BURNING COAL BEDS.—Many coal beds of the western United States are supposed to have taken fire at some time, and quite a number are actually burning. The heat can be felt and kills all vegetation, and smoke is often seen; the fires work back from the outcrop until lack of oxygen smothers the fire; some fires have been traced to 500 ft. from the outcrop. The question is discussed in Professional Paper 108–A of the United States Geological Survey, by G. S. Rodger. The cause of the fire may be lightning, prairie and camp fires and spontaneous combustion. The overlying strata burn into natural brick or terra-cotta; frequently the ground cracks or caves in. Shales and sandstone may be fused into a natural slag, which collects in chimneys; these hard chimneys may survive after the surrounding baked rock has weathered away. Sometimes the slag contains rare minerals.

NOTES FROM THE SOUTH-WEST.

Cardiff.—No material change has been perceptible in the coal market this week. The authorities are shipping heavily, and there is consequently little free coal available, but orders are not entirely lacking, and for the better classes of large coal the limitation prices have been realised both for spot shipment and business ahead. For small coal values continue very weak. In exceptional cases 16*s.* 6*d.*, and perhaps 17*s.*, is obtainable for the best bunker descriptions; cargo qualities are weak all round, and inferiors are practicably unsaleable. Stocks are accumulating, and there is no immediate prospect of an improvement. The contemplated new minimum prices are considerably above current quotations, but conditions at the moment are unusually depressed. In the other sections of the market there has been no new feature, and the current approximate quotations have not varied to any appreciable extent.

Newport.—Western Valley and Eastern Valley coals are maintaining firmly their improved tone, and limitation figures are now being more generally quoted than has been the case for many months back. No exceptional measures, however, have been taken to reduce the surplus of small coals, and for spot positions these are all weak, with prices ruling in some cases under 10*s.* There has been no alteration in values of coke, patent fuel, pitwood or iron ore.

Pooling of New Business.—It is understood that the proposal to pool all new coal export business, which was considered at a private meeting of Cardiff exporters last week, and afterwards dealt with at a representative conference of exporters of the United Kingdom, held in London, has been definitely abandoned. The hostility of the Cardiff representatives to the proposal was supported by Hull and one or two other districts, and the decision arrived at was to make no further alteration in the organisation of the export of the country.

STEEL AND WOODEN SHIPBUILDING IN CANADA.—We read in *The Canadian Engineer* that orders have been placed for steel ships in Canada up to the full limit of all steel plants available during the next 15 months. The question of developing wood shipbuilding in Canada has been under investigation during the last month. It has been pointed out to the Imperial Government that substantial tonnage of suitable wooden vessels could be obtained. In order to assist the development of shipbuilding in Canada, the Dominion Government has offered through the Finance Minister, Sir Thomas White, to find credit to the extent of 10,000,000 dols. for the Imperial Munitions Board for this purpose. This offer has been accepted and will greatly facilitate progress. It is hoped to begin work on a standard type of wooden vessel very shortly, and the building of a considerable number will be arranged for in Canada, where lumber is available in abundance. Sir Thomas White stated recently in the House that orders had been placed by the Imperial Government with Canadian shipyards for the construction of 22 steel vessels having a total tonnage of 175,000 tons, while orders for eight were pending. This will keep all Canadian shipbuilding plants busy well into 1918. The president of the Port Arthur Shipbuilding Company has announced that contracts have been received by his company for work totalling more than 5,000,000 dols. The capacity of the plant is being doubled.

PLASTIC CEMENTS.—The February issue of the *General Chemical Bulletin* contains an article by J. B. Barnitt, on plastic cement, which also appeared in *Metallurgical and Chemical Engineering* of March 15, 1917, and is abstracted in the Journal of the Society of Chemical Industry, of April 30, 1917. We pick out a few notes of interest to the engineer. Plaster of Paris can be made strong by adding asbestos, wood shavings, straw, hair and cloth, or for higher temperatures also stone, glass and other mineral fillers. Hydraulic cement will resist nitric acid; rosin and sulphur are used as fillers. Clay and linseed oil make up good steam joints; for chlorine gas, fireclay is further added; oil vapours are sealed with clay and molasses. Caustic lime and linseed oil are a substitute for putty; the lime may be partly replaced by chalk, but not altogether. Asphalt or pitch (for sticking glass plates together, for coating wood, concrete, steel, &c.) are best dissolved in benzene; paraffin, and also certain oils, may be added to melted asphalt for waterproofing; rosins, wax, plaster and powdered stone may be added to pitch; limestone may serve as powder, but not when acids are to be dealt with. For caulking, pitch, with shellac and rubber, will answer. Waterproofing cements can be made of rosin, wax and powdered stone; sulphur makes these cements hard and durable. A plain rubber cement can be obtained by dissolving crude rubber in carbon disulphide or in benzene; a leather cement is made of asphalt, rosin, gutta percha and much carbon disulphide. Oil vapours at high temperatures will not attack a paste of sodium silicate and asbestos, which are also recommended for the gaskets of superheated steam retorts; the asbestos may be replaced by glass; or zinc oxide and chloride and water, and the corresponding magnesium compounds also make strong durable pastes. To fix glass tubes in brass or iron prepare a stiff paste of litharge and glycerin, or (for high temperature) mix alumina, sand, slaked lime, borax and water. Recommendable core compounds are a little dextrin mixed with much sand and some water; or a stiff paste of powdered anthracite and molasses; also rosin (partly saponified by caustic soda), flour, sand and water; powdered glue may be substituted for the rosin.

AUXILIARY ELECTRIC MOTORS FOR USE IN ROLLING MILLS.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

(*For Description, see Page* 579.)

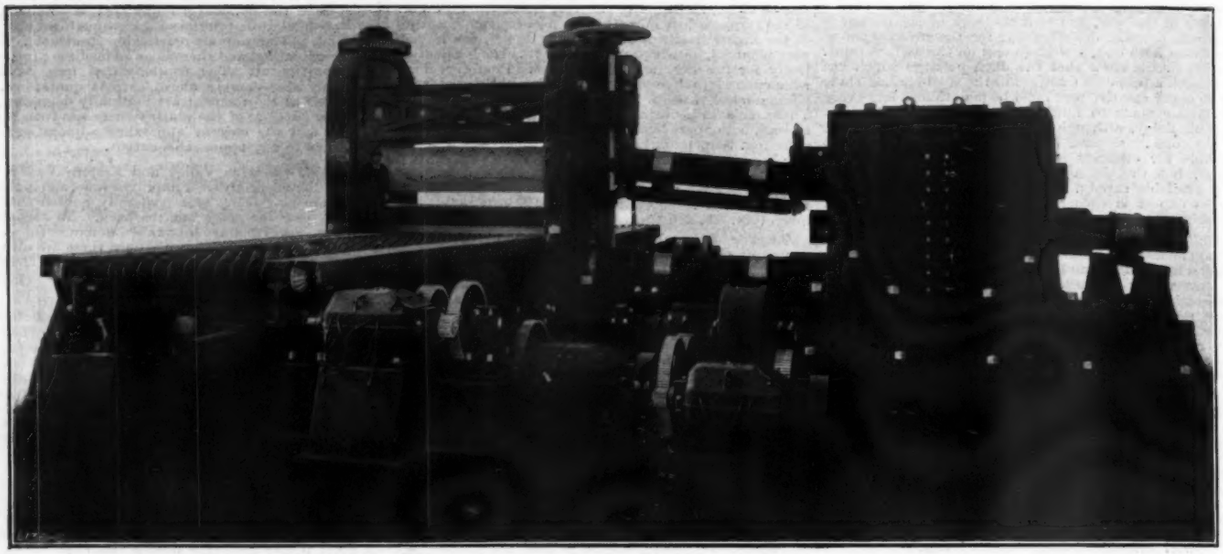


FIG. 1.

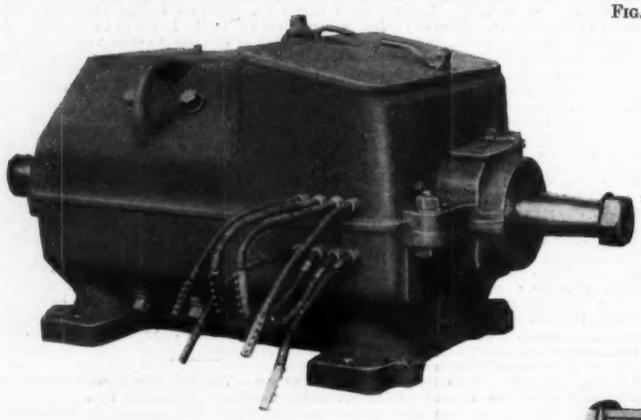


FIG. 2.

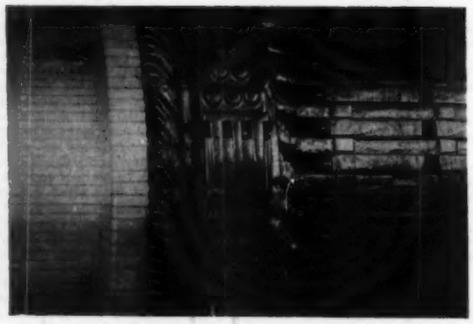


FIG. 4.

FIG. 3.

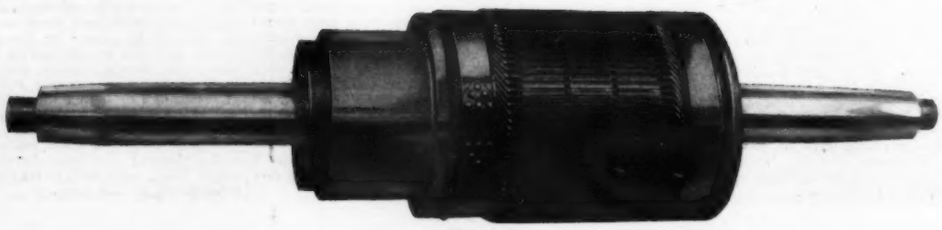


FIG. 5.

MACHINES AND APPLIANCES FOR MUNITION MAKING.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, BARROW-IN-FURNESS.

(*For Description, see Page 564.*)

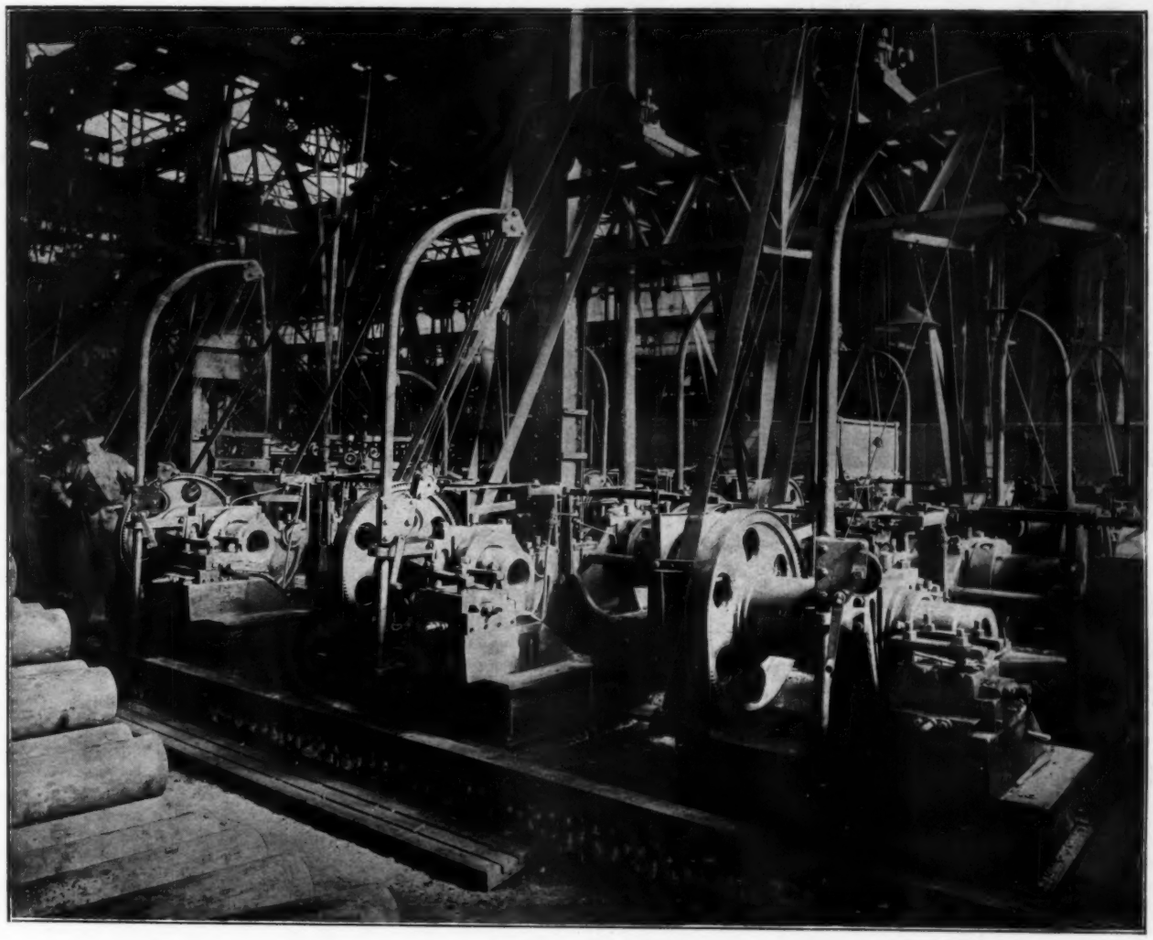
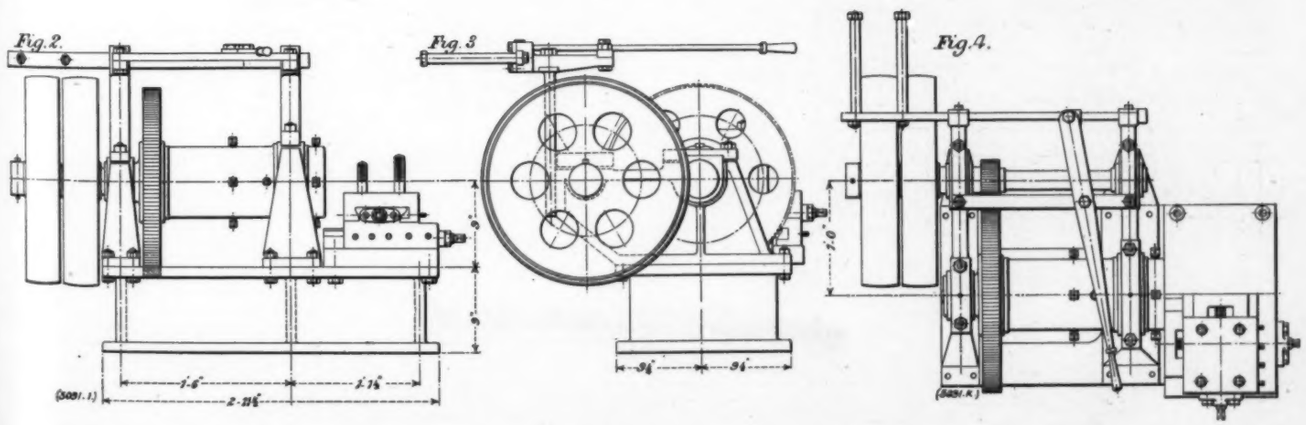


FIG. 1.



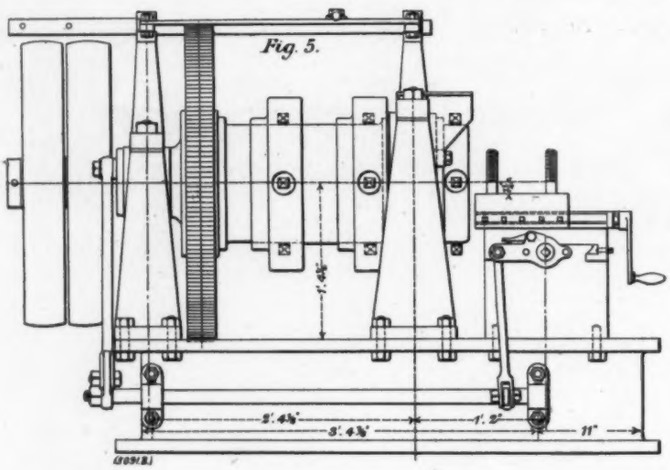
FIGS. 1 TO 4. MACHINE FOR TRIMMING MEDIUM-SIZED SHELLS.

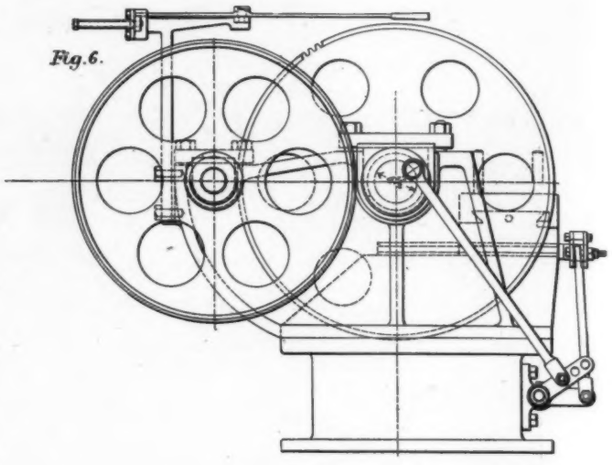
(*To face page 564.*)

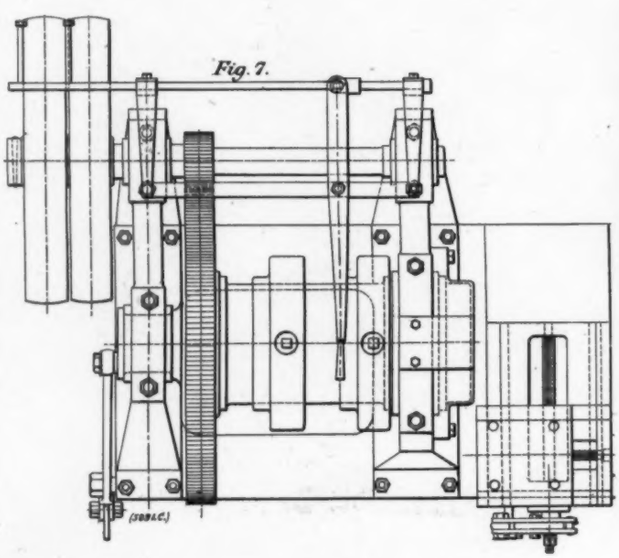
MACHINES AND APPLIANCES FOR MUNITION MAKING.

CONSTRUCTED BY MESSRS. VICKERS LIMITED, BARROW-IN-FURNESS.

(*For Description, see Page 564.*)







FIGS. 5 TO 7. MACHINE FOR TRIMMING LARGE SHELLS.

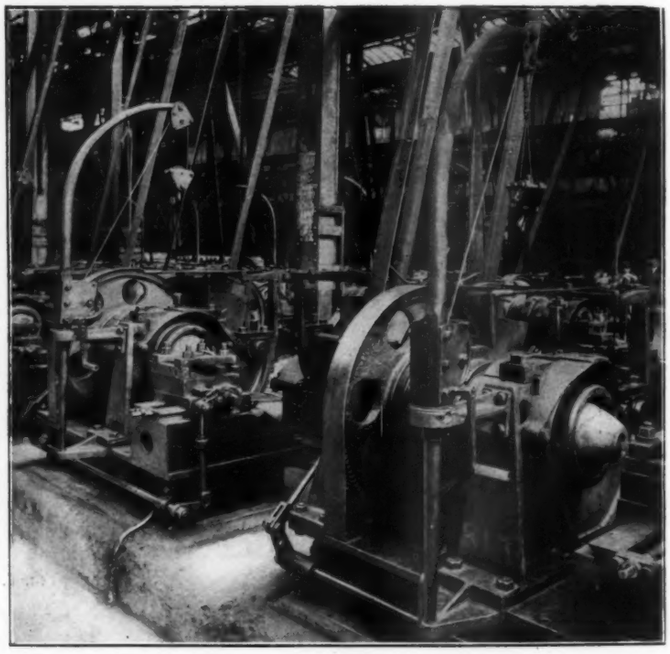
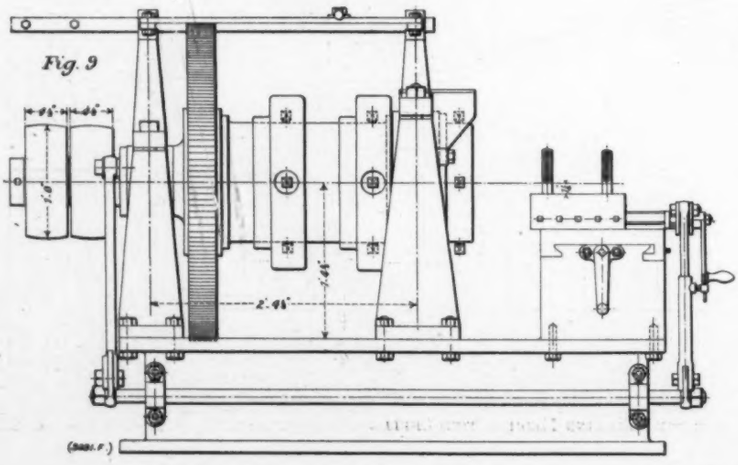
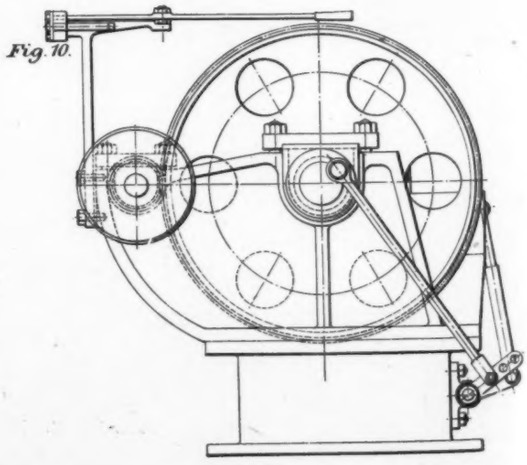


FIG. 8.





FIGS. 8 TO 10. MACHINE FITTED WITH SURFACE FEED GEAR FOR FACING AND BORING NOSE END OF LARGE SHELLS.

MACHINES AND APPLIANCES FOR MUNITION MAKING.

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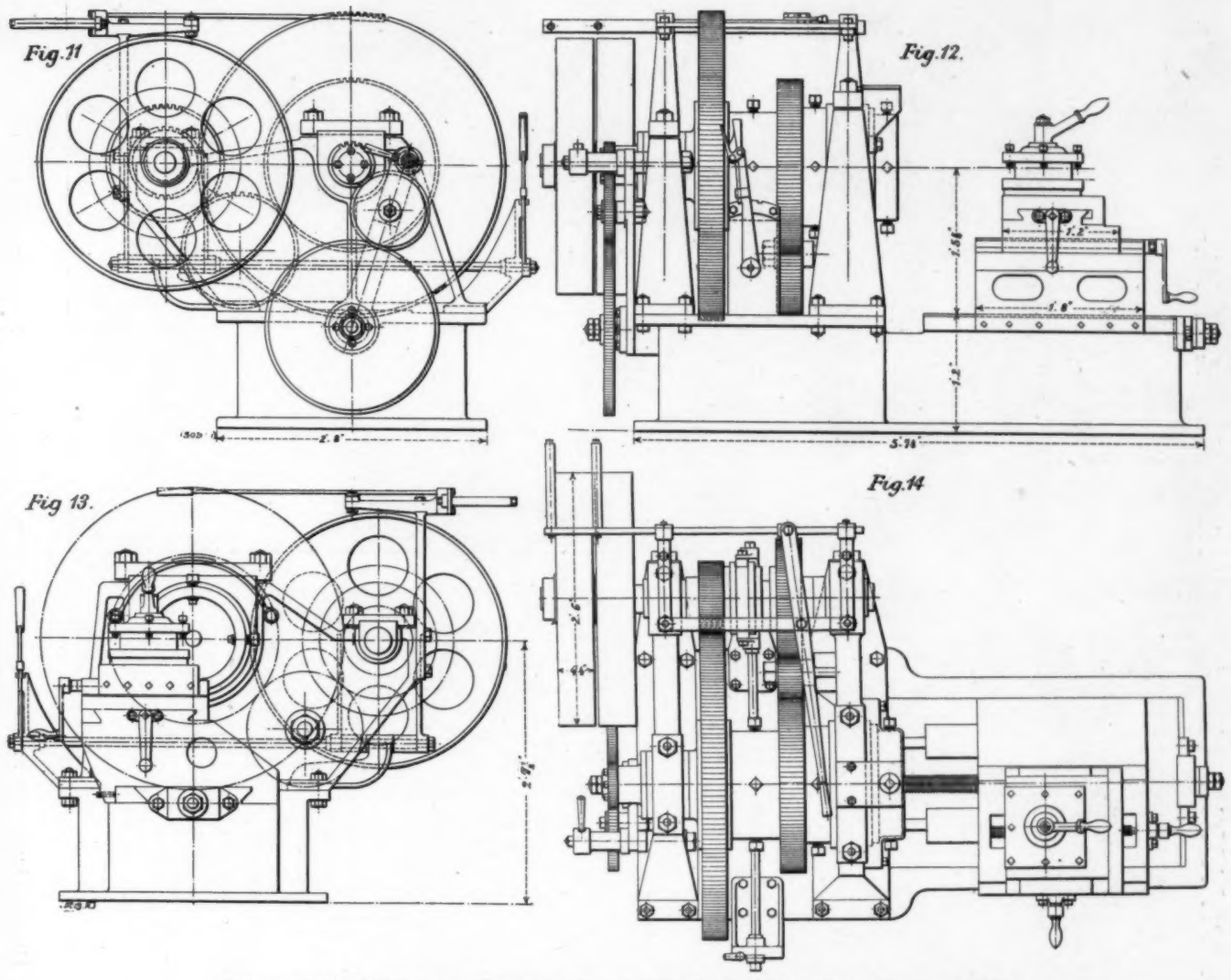
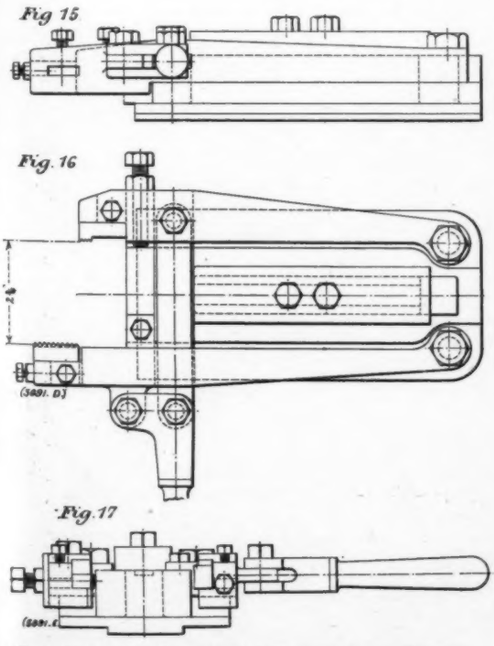
(For Description, see Page 564.)



FIGS. 11 TO 14. MACHINE FOR INTERNAL-SCREWING THE BASE END OF BASE ADAPTOR SHELLS.



FIGS. 15 TO 17. SCREWING ATTACHMENT FOR CUTTING THE THREAD IN THE BASE END OF LARGE SHELLS.

FIG. 18. LIFTING APPLIANCE AT COPPER BAND PRESS.

MACHINES AND APPLIANCES FOR MUNITION MAKING.

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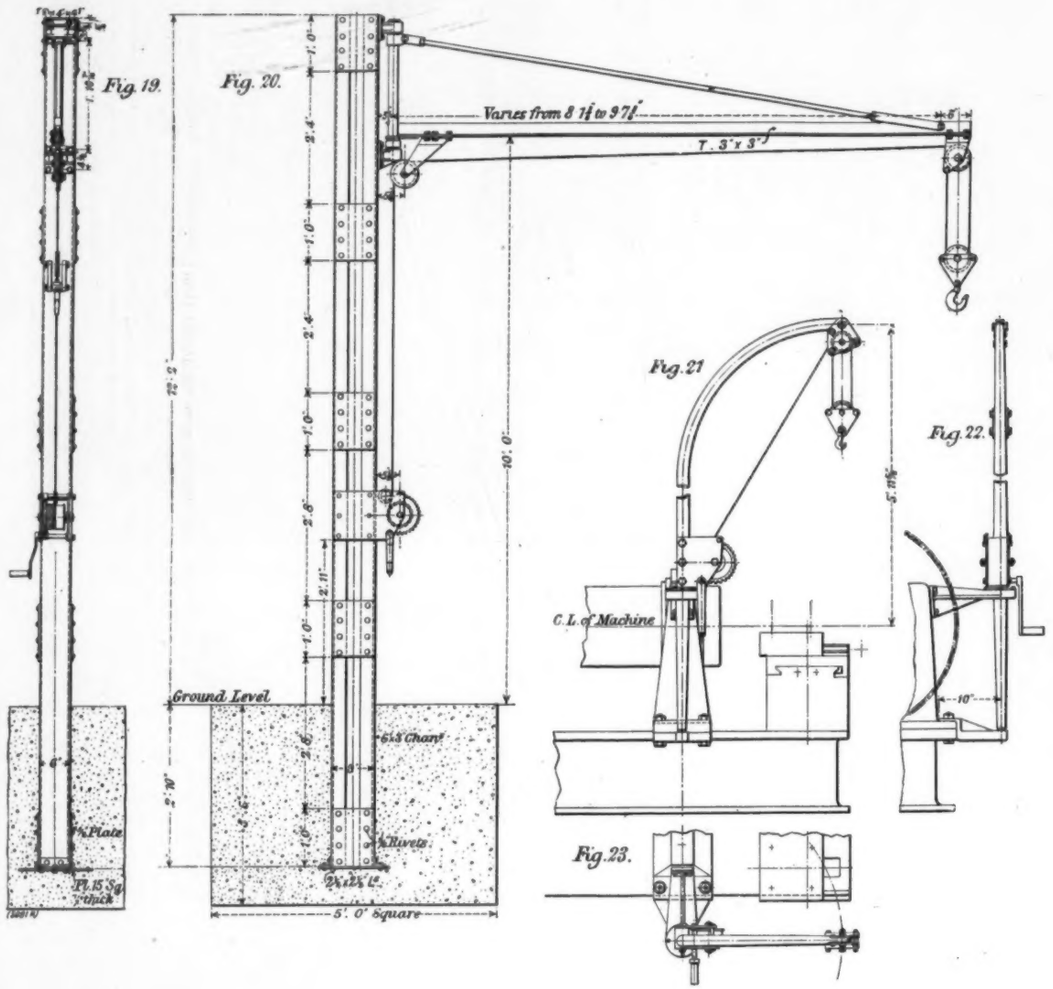
(*For Description, see Page 564.*)



FIGS. 19 AND 20. JIB CRANE FOR DEALING WITH LARGE SHELLS AT LATHES.

FIGS. 21 TO 23. DAVIT ON LATHES FOR LIFTING SHELLS.

FIG. 24. DRILLING MACHINE FOR TAPPING THE HOLE FOR THE RECEPTION OF THE FUSE BUSH.

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Advertisements intended for insertion in the current week's issue must be delivered not later than 5 p.m. on Thursday. In consequence of the necessity for going to press early with a portion of the edition, alterations for standing advertisements should be received not later than 1 p.m. on Tuesday in each week.

SUBSCRIPTIONS, HOME AND FOREIGN.

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Thick " "	£2 9 6

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All accounts are payable to "ENGINEERING," LIMITED. Cheques should be crossed "Union of London and Smith's Bank, Limited, Charing Cross Branch." Post-Office Orders should be made payable at Bedford-street, Strand, W.C. 2.

Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C. 2.

We desire to call the attention of our readers to the fact that the above is our SOLE ADDRESS, and that no connection exists between this Journal and any other publications bearing somewhat similar titles.

TELEGRAPHIC ADDRESS } "ENGINEERING," WESTRAND, LONDON.
TELEPHONE NUMBERS—3863 and 8598 GERRARD.

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With Four One-Page Plates of MACHINES AND APPLIANCES FOR MUNITION MAKING.

NOTICES OF MEETINGS.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, June 20, at 5 p.m., at 70, Victoria-street, Westminster, S.W. 1. Papers to be read:—(1) "The Reduction of Temperature Observations to Mean of Twenty-four Hours, and the Elucidation of the Diurnal Variation, in the Continent of Africa," by Mr. C. E. P. Brooks, M.Sc., F.R.Met.Soc. (2) "Autographic Records of the Air-wave from the East London Explosion, January 19, 1917," by Mr. F. W. J. Whipple, M.A., F.R.Met.Soc. (3) "Some Aspects of the Cold Period, December, 1916, to April, 1917," by Mr. R. C. Mossman, F.R.Met.Soc.
THE AERONAUTICAL SOCIETY OF GREAT BRITAIN.—Thursday, June 21, at 8 p.m., at the Central Hall, Westminster, S.W. Colonel Lord Montague of Beaulieu will deliver a lecture on "The World's Air Routes and their Regulation." The chair will be taken by Major-General R. M. Ruck, C.M.G., C.B.
THE INSTITUTION OF WATER ENGINEERS.—Summer General Meeting, Friday, June 22, commencing at 2.15 p.m., at the apartments of the Geological Society of London, Burlington House, W. A paper will be read and discussed, entitled "Colour Records applied to Potable Waters," by Mr. J. S. Pickering, M.Inst.C.E., Borough and Water Engineer, Cheltenham, Past-President. A discussion on "Water Supplies as Sources of Power" will be opened by Mr. Cecil H. Roberts, M.Inst.C.E., of Aberdeen, Member of Council.

NOTICE TO NON-SUBSCRIBERS.

In view of the restrictions now imposed by the Government on the importation of paper, and of the consequent shortage of supplies, readers who wish to be sure of obtaining "ENGINEERING" each week should place an order for the Journal with a newsagent or bookstall clerk. Owing to the scarcity of paper it will be impossible in future fully to provide for a chance demand for this Journal.

NOTICE.

Owing to the recent Government restrictions, and to the enormous increase in the price of paper occasioned thereby, the Proprietors of "ENGINEERING" are compelled to advance the price of this Journal from 6d. to 8d. per copy. This increase dated from and included the issue of Friday, March 16. The change will not apply to unexpired subscriptions.

ENGINEERING.

FRIDAY, JUNE 15, 1917.

THE PLACE OF SCIENCE.

In a report made in July, 1913, to M. Stephen Pichon, Minister for Foreign Affairs, and published in the French Yellow Book, the vanity of German *savants* is mentioned as largely responsible for the warlike temper then prevailing in the Fatherland. "They want," says the report, "to conquer the intellectual supremacy which, in the opinion of lucid minds, still belongs to France." Subsequent experience has strikingly confirmed the accuracy of this diagnosis, made so many months before the bursting forth of the actual eruption. As protagonists of savagery the professors of Germany have nothing to learn from the most narrow-brained Junker. Quite recently Professor Flamm, the naval architect, advocated the policy of murdering in cold blood the crew of every neutral vessel which the skulking submarines might succeed in overhauling. In the New York *Staatszeitung*, again, another professor complained on the outbreak of the war that Americans actually placed "British and French culture as high above German culture as Germany stands above Russia."

This general refusal to value the achievements of industrious German mediocrities as works of genius caused great resentment in the Fatherland and undoubtedly had much to do with the determination to convince the world that in, at any rate, one department of activity Germany stood supreme. Probably many years will elapse before the full truth is known as to when this resolution was definitely taken, but a letter is extant, written in 1913, in which a leading American engineer warned his correspondent that the representatives of his firm had found warlike preparations in full swing for months past throughout the whole of the engineering and chemical industries of Germany. Factories ostensibly built for the manufacture of electrical machinery were being devoted almost exclusively to torpedo work, and what is more significant than all was his statement that chlorine was being made in enormous quantities and stored for some undiscoverable purpose. Immense sums had been secretly expended on other applications of science to military operations, and confident in the expectation that other nations could only attain an equality of equipment by following the same laborious round, the fatal decision was taken. In fact it would be no exaggeration to say that the war originated in a mixture of stupidity and conceit. The latter is a little less in evidence now than it was two and a half years ago, when the German Press was loud in asserting that the German chemist and the German physicist had worked out infallible methods of destroying the national foes, and to which the inferior intellects of the Allied nations could, it was asserted, make no effective reply.

As the German waiter observed when captured by a regiment of Kitchener's men, which his officers had assured him would crumple up like paper, it turned out "to be very much otherwise," and the conceit which played so large a part in the origin of this world war is now much less in evidence, but the stupidity remains as crass as any exhibited by the Teuton diplomats during the momentous months of 1914.

The chemists, physicists and engineers of the allied countries have effected marvels, some of which were dealt with in the exceedingly interesting Rede lecture delivered at Cambridge last Saturday by Sir Richard T. Glazebrook, Director of the National Physical Laboratory, an institution which during the present crisis has rendered services of inestimable value to the country. In fact it is difficult to see how we could have managed to pull through without the assistance thus afforded. Had the National Physical Laboratory not been in existence we should have had to invent it *ad hoc*, and great as our powers of improvisation are admitted to be, the handicap would have been extremely serious. Munitions interchangeable in every respect had to be supplied in enormous quantities from the most varied and widely separated sources, and made largely by unskilled labour. Most manufacturing engineers professed, no doubt, to work to standard gauges, ensuring the interchangeability of their products, but it soon appeared that, as in morals, profession and practice were frequently somewhat widely divorced. The only consolation is that, as we learn from the American technical journals, matters were little better in the United States, many firms there, as here, proving incapable, without special instruction, of turning out work within the limits of variation demanded. No doubt in some cases these were fixed at absurdly small values considering the character of the work and materials, tolerances of a few mils only being specified in cases where differences of $\frac{1}{10}$-in. would not have affected the utility of the product. Admittedly there were a considerable number of such deviations from common-sense embodied in the specifications issued, but, unquestionably, an immense amount of work had to be done, and done at short notice, in which but very small tolerances were permissible, and to attain this end on a manufacturing basis, gauges had to be supplied on a stupendous scale.

Sir Richard Glazebrook stated in his lecture that some 400,000 gauges had been tested at Teddington during the last 18 or 20 months. For some obscure reason the country of Whitworth had come to rely for such articles almost exclusively on foreign sources, and when the call came for the manufacture to be resumed the results were at first lamentable, rejections being very numerous. Now, Sir Richard states, 80 per cent. pass as a matter of course, and some makers get practically all their gauges through. The rate at which these tools are now being received and examined is 10,000 a week, and a description of the methods used in the testing of this huge quantity would be of great technical interest, but presumably nothing will be published on this head till the end of the war. As for screw gauges, not a few engineers were inclined to believe that the limits of accuracy called for were unnecessarily, indeed almost impracticably, close, but we understand that this difficulty has been overcome, and that at least one maker gets 97 per cent. through, the work being done by girl labour and the output per employee being very high.

It is one of the commonplaces of human history that much, perhaps the major part, of the advance made in the arts of civilisation has originated in the call to meet military requirements. Man has never grudged expense for his defence or his amusement, and arts which have been developed in the first instance to meet one or other of these demands have proved of almost universal utility. The

(To face page 585.)

present world war has seen an enormous destruction of wealth, but it has at the same time demonstrated unsuspected possibilities of creating new wealth on a vaster scale than ever before. It has, in the first place, conclusively proved that a great part of repetition work is never skilled work, and should in all departments of industry be open to every willing worker without restriction, whatever his previous history or training.

In the second place it is to be hoped that our administrators, both of public and private corporations, will realise in a way almost unknown here in the past the real practical advantages to be derived from expert scientific assistance. Without such aid many of our essential industries must, during the past two years, have come to a standstill with the loss of supplies previously obtained from the enemy. Many varieties of optical glass, many dyes, chemicals, and refractory materials were obtained wholly from foreign sources. This condition arose, at any rate in part, from the reluctance of the average works management to consider anything but administrative ability as necessary for efficient operations. The extraordinary advance which has been made in aeronautics is eloquent of the fallacy of this thesis. More progress has been made during the past 30 months than would have resulted from 10 years of peaceful development. This has been very largely due to the experimental and theoretical investigations made at Teddington, owing to which the resistances to motion have been so reduced in the most modern machines that the authorities have considered it advisable to dispose of a large number of the older types, since the engines can be used to so much greater advantage on the newer. Speaking at Cambridge, Sir Richard Glazebrook quite legitimately drew attention to the large share which that University has played in this development. Experiments on models teach us much, but it was in the process of testing by actual flight the reliability of the results of experimental and mathematical investigation that E. H. Busk and Keith Lucas, both Cambridge men, lost their lives, and their work, Sir Richard Glazebrook stated, is now being continued by two other *alumni* of the same University, Messrs. Farren and Paget Thomson.

Similar methods would undoubtedly lead to equally notable developments in many of our industries; but here we have to fight the handicap imposed by our systematic neglect of science as a branch of culture. The most the upholders of the purely classical tradition of our public schools are disposed to grant is that boys not clever at classics should be given the choice of taking up science. Since, however, it is commonly the boy who is good at the one who will also be good at the other, this means that an overwhelming percentage of the cleverer youths will be compelled to whet their wits on the intricacies of the Latin and Greek grammars, in place of acquiring the wider culture offered by scientific studies. One plea advanced in support of this policy is based upon the assertion that Latin has been taught so long that exercises suitable to almost any stage of mental development are at the disposal of the competent teacher. What may be the substance of this plea we are not prepared to say, but, admitting it to the full, it does nothing more than point to the pressing importance of substantial reforms in our methods of teaching elementary science and mathematics. Sir Richard Glazebrook is himself strongly impressed with the desirability of important changes in this regard. He observes "that a plan which is excellent for men who intend to specialise in science is not that best suited to give to all some knowledge of the relation of the sciences to one another and a just conception of the means by which they advance."

This view will, no doubt, be condemned by Professor Perry and Professor Armstrong, but it is in close accordance with what has been repeatedly urged in these columns. We would, however, go farther, and insist that even those who do intend to take up science or mathematics would benefit if elementary courses were designed for breadth of view rather than depth. Much less insistence should be laid on laboratory work and much more on the history of scientific and mathematical developments. The theories and theorems which the youth finds in his text-books did not arise fortuitously, but, as in more material matters, it was necessity which proved the mother of invention. If treated from this point of view the subject can be made of interest to circles much wider than those to which scientific studies now appeal, and it is of the utmost importance to the nation that those who direct either our public services or our privately owned manufacturing establishments shall show a much greater appreciation of scientific methods and principles than they have in the past.

WATER POWER IN CANADA.

MANY circumstances have contributed to give to Canada the prominent position she now occupies, but if these be analysed it will probably be found that the first place should be assigned to her magnificent waterways. In the old days these supplied facilities for exploration, and later, when population was still scant and capital lacking, they rendered the lumber industry possible and were pioneers in development. To-day, by utilising hydraulic power as a source of mechanical energy, they have become the dominant factor in accelerating progress. Hydro-electric power has there found a wide field of enterprise, and fortunately one that statesmen and engineers alike are using wisely and beneficially. What coal and steam power have been to Great Britain, abundant water supply is to Canada. What advantages have been conferred upon England by these sources of wealth and given her a controlling position among neighbouring nations, similar advantages and influence are promised by Canada's rivers, fed without stint by a perennial rainfall and flowing through a vast territory presenting every variety of topographical feature, that adds a commercial value to picturesqueness. Coal is but a wasting and an irreplaceable asset, destruction—and extravagant destruction—is necessary for its utilisation, quickened industry implies a shorter life; but each year renews Canada's stores of energy, and her only care need be to regulate the generous abundance throughout the changing seasons. Our short river courses, gently meandering through a comparatively level country, do not permit us to appreciate adequately the enormous forces latent in the magnificent masses of water that tumble down mountain and gorge and pass, placing practically limitless power at the command of the Dominion. The greater the harvest to be gathered, the more imperative does it become that the extent of the resources awaiting development should be appreciated. With the view of a wider dissemination of the facts, the Water Board, under the direction of J. B. Challies, C.E., is pursuing a policy that should have a favourable result, for by publishing descriptive monographs from time to time, the world is informed of what has been achieved and what the future has to offer. Several of these have been noticed at length in these columns, and it is intended to call attention to others which detail the successful solution of problems in hydraulic engineering, or exhibit notable advances in the development of these gigantic undertakings. The administrative and economic problems on which the pursuit of a successful policy depends are not less important than the engineering feats, and deserve as close attention. The recent issue, under authority, of one of these monographs,* by Mr. C. H. Mitchell, C.E., provides a fitting occasion for examining the general problems concerned with the utilisation of hydraulic power, as they appeal to the engineer, and also the employment and distribution of that power as it affects public convenience.

Statistics and diagrams are inadequate aids to the imagination when vastly disproportionate quantities have to be compared, but it is necessary to give some figures to show the commanding position Canada, only a recent competitor in this field, has won for herself and the extent of the untapped sources that stand at her disposal in the near future. With the growth of settlement it may be anticipated these natural but little-known resources will decide the centres of population, otherwise it is inconceivable that the energy remote from existing consuming centres will be commercially developed within a reasonable period of time. It is as fortunate as it is remarkable that the cities of Canada lie without exception within the zone of economic electrical power supply from hydraulic sources. At the present moment attention may be profitably confined to "populated" Canada, leaving out of consideration the vast portion of the Dominion lands washed by the Arctic Ocean, with much of the Yukon district. This limitation has the advantage of restricting the area to the districts where storage has found useful employment and in which the water capacity has been estimated with some close approximation.

The following table, compiled from the latest figures available, explains itself, and would have been more instructive if Mr. Mitchell had given similar data for a past epoch, indicating the rate of progress.

Country.	Area, Square Miles.	Population.	Horse-power Available, 1915 Estimate.	Horse-power Developed, 1915 Estimate.	Per Cent. Utilised.	Horse-power per Square Mile of Area.		Horse-power *per Capita*.	
						Available.	Developed.	Available.	Developed.
United States.. ..	3,026,600	92,019,900	28,100,000	7,000,000	24.9	9.3	2.31	0.31	0.076
Canada	927,800	8,000,000	8,094,000	1,700,000	21.0	8.74	1.83	1.01	0.21
France.. ..	207,100	39,601,500	5,587,000	650,000	11.6	27.0	3.14	0.14	0.016
Norway	124,130	2,302,700	5,500,000	1,120,000	20.4	44.3	9.02	2.39	0.487
Spain	194,700	18,618,100	5,000,000	440,000	8.8	25.7	2.27	0.27	0.024
Sweden	172,900	5,521,900	4,500,000	704,500	15.6	26.0	4.08	0.81	0.127
Italy	91,280	28,601,600	4,000,000	976,300	24.4	43.8	10.7	0.14	0.034
Switzerland	15,976	3,742,000	2,000,000	511,000	25.5	125.2	32.0	0.53	0.137
Germany	208,800	64,903,400	1,425,000	618,100	43.4	6.8	2.96	0.02	0.010
Great Britain ..	88,120	38,802,500	963,000	80,000	8.3	10.9	0.91	0.02	0.002

It is our misfortune that, of all countries in the table, we have the smallest amount of horse-power available, but it is not creditable to our enterprise or our prudence, though it may admit of explanation, that we have developed the smallest percentage and show the least horse-power *per capita*. The relation between population and water power involves many variables, as environment, Government policy, vested interests, competing sources of power, access of markets, and, above all, the promotion of electric power at low cost. All these and many others have contributed to assigning us the lowest position in the table. In this country high heads with large volume of water do not exist. The installation of hydro-electric power involves heavy outlay of capital, and competition with steam plant is a threatening factor. The importance of low-cost power as a governing element in the industrial world must be admitted, but low-cost power does not admit of absolute definition. Mr. Mitchell reminds us of the obvious fact that under certain conditions steam power at 100 dols. per horse-power per year is low-cost, and electric power at 6 dols. per horse-power per year high-cost power. The only point to be considered is that at which manufacture becomes commercially feasible: the field of industrial enterprise, however, is narrowed; electro-chemical and electro-metallurgical operations may be entirely excluded on the ground of capital cost.

The table emphasises other results than our shortcomings. It shows that while the United States lead in available capacity and in power developed, Canada, in spite of her limited population, has pushed the development of her resources to nearly the same percentage, and the developed horse-power per head is three times that in the States. The annual rate of development in Canada is probably much more rapid, for between 1911 and 1914

* "Canadian Hydraulic Power Development and Electric Power in Canadian Industry." By Charles H. Mitchell, C.E., Consulting Engineer to Branch. Ottawa. Printed by J. de L. Taché, 1916.

the horse-power in use increased from 1,016,521 h.p. to 1,712,913 h.p., showing that the 8,000,000 h.p. has already been drawn upon to such an extent as to need husbanding, and will probably make the acquisition of some of the 10,000,000 h.p. existing and wasting in the less accessible districts a desirable asset. The mechanical difficulties will be great, but in tapping these distant resources we may expect to see some new problems of hydraulic engineering handled with efficiency and boldness.

Norway, having the smallest population, heads the list in amount of developed horse-power *per capita*, and Germany, alive to the need of utilising all available energy, can boast the highest percentage of developed horse-power. These statistics must necessarily date before the war, and as it is known that Germany has shown a feverish haste to turn her water power to account, it is not impossible that she is approaching the limit of capacity she possesses. For though the supply is renewed year by year, it is strictly limited in amount; if we are willing to use the stores of coal for fuel, there is no similar check on the amount of energy available in any one year.

Hydraulic facilities are by no means uniformly distributed throughout the Dominion. The maritime provinces of Nova Scotia, New Brunswick and Prince Edward Island, having a limited drainage area, where the rivers, owing to the general topography of the country, offer only low heads, cannot command more than 35,000 developed horse-power. Quebec and Ontario enjoy enormous possibilities, arising mainly from the lake formation, and the two provinces consume nearly 80 per cent. of the total developed horse-power. Manitoba, and in even more marked degree Saskatchewan—the prairie wheat-growing provinces—are deficient in water power, and make a very moderate demand on the total, for, including Alberta, the entire amount is under 100,000 h.p. But even this moderate aggregate, be it remembered, is more than the total output in Great Britain. Further West, in British Columbia, the supply again becomes ample, the Rocky Mountains and the neighbouring foothills offering an enormous water-power development, of which some quarter of a million horse-power is at present utilised.

It is not a little remarkable that these stores of energy, so overwhelming in the aggregate, find their chief application, not in industrial loads, as generally understood, but in domestic service. The infinitesimal foot-power of the humble sewing machine is not disregarded in Canada. Mr. Mitchell informs us that the genesis of the present power service is to be traced to the prospects the domestic service originally offered, and to-day it is usually the personal aspect and home convenience of electrical power that is the determining factor in the establishment of a publicly-owned system or the granting of service franchises. Municipal needs, such as pumping, street lighting and traction, limited to urban, interurban and terminal locomotion, utilise no small percentage of a mixed-power load that displays its convenience in many unexpected ways. In the absence of any active competition the facilities are supplied to the public at very attractive rates. Domestic lighting rates bear a service charge of 3 cents or 4 cents per 100 sq. ft. of floor area per month, and a standard rate of from 2 cents to 7 cents per kilowatt-hour. The average rate paid for domestic service is calculated to be 3.7 cents per kilowatt-hour. Nevertheless electrical distribution in this way has proved a successful commercial undertaking.

Canada early recognised the importance of possessing the water rights throughout the Dominion and of controlling the disposal of water power. By the exercise of a prudent foresight the Government, either through the Dominion or provincial administrations, has supreme authority on all navigable rivers. In some of the older Colonies water powers are privately owned, but throughout the Continent a firm and efficient control is maintained that ensures an adequate and uniform development of all sites and secures the best possible distribution to the public. But while protecting the public and maintaining supervision of all developments with the view of promoting thorough economic utilisation, the general policy aims at fostering legitimate private enterprise.

A good illustration of judicious management of publicly-owned power is furnished by the Hydro-Electric Commission of Ontario, where a scheme has been elaborated on such wide and intelligent lines, and with such pronounced success, that the administrative machinery is worthy of close study. Mr. Mitchell's description of the growth of this huge and elastic scheme is of particular interest, and we regret not to be able to follow it in detail. More than two years ago the transmission lines aggregated 396 miles of double circuit and 37 miles of single circuit 110,000-volt line, 722 miles of single and double-circuit pole lines of voltages from 13,200 to 46,000, and 77 miles of low-voltage circuits. The number of municipalities embraced in the scheme was originally 15, it is now 82, and the number of consumers has long since passed the 100,000 mark. The annual increase is at the rate of 30,000 a year. In estimating the causes of success three factors attract attention—firstly an attempt is made to cater for every class of consumer, secondly, the equipment and general design is selected for permanent and effective service, and, lastly, power is supplied to the municipalities at cost price. The plan as devised had to meet and overcome the ordinary criticism that every monopoly has to encounter, but aggravated by an interested opposition, the product of provincial party politics based on the admitted experimental character of the scheme. We are glad to be able to quote Mr. Mitchell's testimony that, whether regarded as a commercial system, as an engineering work, or as a public undertaking, the entire success of the scheme has justified its adoption. The success of the commercial undertaking is proved by the annual net profits earned and the accumulated surplus, the two together being no small percentage of the original cost. The continuity of the service, and the maintenance of a definite standard of electrical characteristics of the supply, vouch for the excellence and efficiency of the scientific arrangement, while the increase in the number of consumers guarantees its popular character.

We do not propose to describe here any of the typical Canadian power developments or the engineering features involved in the design, construction and operation of the hydraulic plants. The general character of the schemes, as well as the necessary modifications in design, can be more conveniently considered in connection with particular installations. Hydraulic engineering has not approached conditions of complete standardisation, and every new undertaking presents fresh problems for which ingenuity has to find a satisfactory solution. Dams, conduits, turbines, regulating devices, have all undergone much change, but still offer opportunities for original treatment, and though improvement in every direction is noticeable, it is in the successful combination of details that room for the greatest efficiency is found. Scant justice would be done to much brilliant and original work if we disregarded the conditions that compelled its adoption.

The numerous power projects in existence or contemplated might seem to have exhausted all the problems water storage can offer, but in Canada, where the sources may be mountain streams, glaciers and snowfields, where the winter changes retard the discharge by severe frosts, and the summer heats promote excessive evaporation, the conservation of water is ever liable to enter on a new phase. Pondage, or the daily storage of water available at the turbines, acquires a new importance when ice threatens to interrupt the operation of hydraulic plants and bring the throbbing life of a huge city to stagnation.

Local applications have necessitated radical modifications in turbine construction where large capacity and comparatively high speeds have been used to develop low heads. The installation of units of 20,000 h.p. capacity under a head of 76 ft. at a speed of 120 r.p.m. may be considered a satisfactory performance, but units larger and with a higher specific speed are now at work. To obtain high efficiency and good inherent regulation of turbines, the greatest refinement in the construction of water passages has to be exercised throughout the whole system. We hope to have an opportunity of illustrating some of the most recent improvements when describing the Kananaski Falls on the Bow River. To the employment of wood-stave pipe for water conduits we have recently referred, but the Canadian engineers seem to have simplified the plan by using a half-round open section constructed of British Columbia fir, which has been found effective and reliable for long service. The general experience has been that the rotting of the wood is not a serious factor, and if the conduit is full of water under a pressure sufficient to cause saturation of the staves, rotting is entirely absent. The trials cannot, however, be of many years' duration, and further experience is needed. Relief valves for the discharge of surplus water where long conduits are in use have been improved till they have attained a stage of comparative perfection. The description of the character and operation of these and other devices is, however, best deferred till a complete installation is under consideration, when their leading features can be adequately illustrated.

THE ELECTRICAL PROPERTIES OF GASES.*

ON Saturday last Sir J. J. Thomson, O.M., P.R.S., delivered at the Royal Institution the concluding lecture of his course on the above subject.

In this last lecture he proposed, he said, to consider the application of some of the results demonstrated on previous occasions to certain important questions in general physics. Of these, the first was, What was responsible for the luminosity of gases? He had shown that in a discharge tube the luminosity varied from point to point, so that in some parts there was an absence of light, whilst other parts were bright. These variations in the luminous appearances ought to give some information as to what influenced the emission of light from gases. The theory of striations showed that in certain parts of the tubes in which they appeared there was no ionisation of the gas present. The operation of ionisation consisted in splitting up the molecules of a gas into negative and positive residues, and it might be that the production of light was the result of ionisation. If so, two questions arose. In the first place, was ionisation a necessary condition for luminosity? or, in other words, when we got light, did we also always have ionisation? There was ample evidence that ionisation had certainly a good deal to do with luminosity, as he had shown in an experiment (previously reported) in which electrons produced from a hot wire were squirted through a gas. In this case, unless the speed of the electrons was increased beyond a certain definite limit no visible radiation was emitted by the gas. When, however, the speed of the electrons exceeded a certain critical value, the gas became luminous and concurrently the strength of the current went up, which was evidence of ionisation of the gas. There was thus undoubtedly a close correspondence between ionisation and luminosity. Admitting this close association between the two, the question remained as to whether ionisation was essential.

The evidence showed that there were cases in which luminosity was not attended by ionisation. In this connection it was important to bear in mind that it was very much easier to detect ionisation than luminosity. The tests for ionisation were of extraordinary delicacy, as was indicated by the fact that it was possible to detect four or five ions in a cubic centimetre of gas containing some 2.75×10^{19} molecules. If this ionisation were accompanied by radiation the energy of this was far too small to be detected by the eye or by the longest possible exposure of a photographic plate. The tests for ionisation were, therefore, so delicate that it was possible to say with confidence that some few cases were known in which we had luminosity without ionisation. One of the most interesting of these was afforded by iodine vapour, which phosphoresced when exposed to the action of ultraviolet light. Tests for ionisation when the gas was thus emitting light showed no conductivity. Nevertheless it had been found that, if not actually ionised, some progress had been made towards such a condition, as the

* ERRATUM.—In *Fig.* 1, page 549 *ante*, for "Sparking Distance," read "Quantity of Gas."

vapour was more easily ionised when phosphorescing than when in its natural condition.

Anthracene vapours, and those of some other compounds characterised by the presence of the benzene ring, fluoresced under the action of ultra-violet light, and here, again, there was no ionisation. These cases seemed to be exceptional, but were perhaps only apparently so, the luminosity being due to a process very similar in kind to ionisation, which consisted essentially in the separation of an electron from an atom of the gas or vapour. It was, however, possible to imagine cases in which the shift of the electron was not sufficient to take it outside of the sphere of action of the atom.

The electrons might be looked on as the mortar binding together two atoms of a molecule. The suggestion therefore arose that the luminosity unaccompanied by ionisation was due not to the ejection of an electron, but to its transference from one position in the molecule to another. In chemical language this would correspond to an alteration in the bonds connecting the atoms together. Thus two atoms doubly linked in the normal state, as O = O, might be altered so as to be singly linked thus, —O—O—. We would thus get a movement of an electron of the same kind as in complete ionisation. But this movement would be wholly intra-atomic or intra-molecular. He thought that some action of this kind was responsible for phosphorescence.

In certain cold flames, again, there were no traces of ionisation, but there might be here, as in phosphorescence, a sort of quasi-ionisation, giving similar results in the matter of light emission.

Again, there were many cases of ionisation unaccompanied by any visible production of light. An instance of this was afforded when gases were ionised by Röntgen rays. This might be due to the difficulty of detecting light. Summing up, it might be said that there was certainly a close connection between ionisation and luminosity, but it would be going too far to say that complete ionisation was essential to the production of light.

In any case ionisation was never permanent. The missing electron was, sooner or later, always replaced, and a point of interest arose as to at what stage of the process between the loss and the replacement of an electron was luminosity produced. Was it when the electron returned or when it was ejected? The study of striations threw no light on this matter, but there was independent evidence which indicated that it was the return of an electron to the atom which gave rise to luminosity.

He had, the lecturer continued, made some experiments not very long ago which threw light on this point. He was investigating the production of ionisation by a form of radiation intermediate between ordinary Röntgen rays and ordinary light. These "soft Röntgen rays" were produced by the impingement on solid particles of electrons moving at different speeds. It turned out that no radiation whatever was produced until the energy given to these electrons exceeded that due to a fall through some 15 volts to 20 volts. At this limit a small amount of these soft radiations was emitted, which increased as the voltage was raised. The type, however, varied very little even when the fall was changed from 20 volts up to 100 volts or 200 volts. Through all this range by far the greater part of the radiation produced was of the same type as that produced by the 20-volt drop. It was not wholly of this type, since there was an admixture with other constituent radiations which increased with the energy given to the electrons, but nevertheless, the major proportion of the total remained unchanged in character in spite of the large increase in voltage. A point was, however, at length reached in which a further addition to the energy of the electrons led to the emission of a different type of radiation, which in its turn persisted through a considerable range of voltage. As before, there were stray constituents depending upon the energy supply.

These peculiarities were easily explainable if the radiation was due to the replacement of a lost electron. The energy involved in this would be always the same, whatever the speed of the electrons which had effected the original ionisation. With a certain energy in the colliding particles electrons would be detached from one position in the atom, but to knock off other electrons from other positions the energy would have to be increased. There was thus reason for believing that in the main luminosity resulted from the return of an electron to the positive residue of an atom.

It was, the speaker continued, possible to have several types of positive residues. Positive rays, for example, were found consisting of atoms carrying one charge, and also of atoms carrying two positive charges. Thus, if an electron returned to an atom which had only one positive charge the result might well be different than when it returned to an atom showing two positive charges. Indeed, Stark had been able to distinguish certain spectral lines as due to residues having one positive charge and others as due to doubly-charged residues. This fact was connected with some extraordinary changes in the colour of certain gases when the character of the discharge through them was altered. A notable instance was afforded by argon. A tube charged with this gas emitted light of a purplish colour when the discharge through it was derived from an ordinary induction coil; but when Leyden jars were included in the circuit the light was of a bright steel blue colour. Hence by altering the conditions of the discharge it was possible to change the type of luminosity given out. The difference might be due to there being a great preponderance of singly-charged residues in the one case and of doubly-charged residues in the other.

Although the luminosity was due to the return of an electron to the atom, previous ionisation was essential. More energy was required to ionise one kind of atom than another. Hence in a mixture one kind might be excited to luminous emission and not the other.

This the lecturer illustrated by placing a bulb, filled with a mixture of hydrogen and chlorine, as secondary to a coil traversed by very rapidly alternating currents. The hydrogen was, he stated, more easily ionised than the chlorine, and the green light from the latter gas was accordingly only visible near the surface of the bulb, where the field was very strong. The inner layers showed only the red of hydrogen, as in these inner regions the negative particles did not acquire sufficient energy from the field to ionise the chlorine.

Summing up, to produce luminosity it was necessary in general to have positively electrified atoms to which electrons could return. There was one method known, the lecturer continued, by which it was possible to obtain such positively electrified particles in great number. It would be a complicated matter to use discharge tubes filled with potassium or sodium vapours; but a large supply of positively charged atoms of these elements could be obtained by coating the positive electrode of a tube with a paste made up out of their iodides or other similar salts. When the discharge passed the positive electrode got hot and the salts evaporated, and a stream of positively electrified ions was obtained, which had very considerable luminosity.

A point of some difficulty arose in attributing luminosity to the return of an electron. There was reason to believe that the hydrogen atom had only one electron, since in positive ray analysis no hydrogen atom was ever found to have lost more than one electron. How was it, then, that from this single positive residue and this single electron that we got the complicated hydrogen spectrum. He did not refer here to the second spectrum of hydrogen, with its almost infinite complication, but to the ordinary spectrum as represented by the Balmer series of lines. It would be natural to expect that from a combination of one electron with one positive particle symmetrically placed, but one spectral line should result, but actually there was a practically infinite number.

One view advanced amounted to this: that there were practically an infinite number of kinds of hydrogen atoms. It was, in fact, quite possible to make up an infinite number of neutral atoms consisting of a positive particle in equilibrium with a negative one. Such an equilibrium showed that there must be a repulsive force to keep the two apart. One way of providing for this was to attribute the repulsion to centrifugal force, and by suitably altering the speed it was possible to get, on this hypothesis, a hydrogen atom of any size. This, however, did more than was required, since in that case the series of lines would merge into a continuous spectrum. Something more was necessary. Those acquainted with hydro-mechanics would know that in a vortex ring in a liquid the speed of a particle was governed by the relation $v\,r$ = constant, where v denoted the speed and r the radius of the path. This held wherever might be the centre enclosed. If, however, two centres of vorticity were enclosed the value of $v\,r$ would be doubled, and if three centres were enclosed it would be tripled. Assuming the repulsion of the electron in a hydrogen atom to be due to centrifugal force, the value of this force was $\frac{v^2}{r}$, which might be written as $\frac{v^2 r^2}{r^3}$. For equilibrium in its orbit this force must balance the attraction between the electron and the positive charge. Hence, if $v\,r$ represented circulation round a vortex ring the electron would be in equilibrium near in if it enclosed one centre, but if it enclosed three it must be farther out. Hence possible positions varied by jumps.

This, the lecturer continued, represented one way of regarding the origin of the hydrogen spectrum, but it was not in accord with chemistry, since the amount of energy required to ionise the atom would differ with the different positions of the electron. The chemical properties depended upon the energy required to separate the electron from its atom, and hence, on the view above explained, we ought to find that some hydrogen atoms were more electro-negative than others. So far there was no evidence in support of this. It had, however, to be borne in mind that much yet remained to be discovered, and that such a difference would not be found unless specially looked for. It was, therefore, quite possible that if chemists set themselves to investigate this point confirmatory evidence might be forthcoming. At the present time, however, the theory just explained was not backed up by any chemical evidence.

There was, however, another way of regarding the matter. The field of force between the electron and the positive charge might be represented by lines of force stretching from one to the other.

It we regarded these as having a material existence and shot an electron between them at a high speed they would be disturbed, and we might thus get vibrations of the lines of force independent of the electron to which they were attached. In this way we might derive a very complicated spectrum from a system consisting of but one positive and one negative particle.

Coming next to the structure of the atom, the lecturer said he would consider first the characteristic Röntgen radiations which could be derived from atoms. These Röntgen rays were an extreme case of light rays, and were just as characteristic of a particular atom as was its ordinary spectrum. These Röntgen-ray spectra were, however, of such simplicity that the laws which governed them sprang out in a way which was not possible with such entangled sets of lines as formed the luminous spectra.

Mr. Mosley (whose death on active service had been so great a loss to science) had shown that the frequency of the characteristic Röntgen radiation from any element was proportional to the square of the "atomic number." This atomic number must be distinguished from the atomic weight. It denoted merely the order in which the elements came when arranged according to their atomic weights. Thus the atomic number of hydrogen was 1, that of helium 2, of lithium 3, and so on. Theory indicated that the atomic number was proportional to the number of free electrons in the atom. In formulating his law Mosley had to suppose that two elements still remained to be discovered.

The connection between the atomic number and the atomic weight was of extreme interest. The most characteristic feature of the list of atomic weights was their tendency to approximate to whole numbers, although the differences were appreciable in some cases. In the case of the smaller atomic weights the difference was nevertheless astonishingly small, and it was quite out of the question that it could be a mere matter of chance. We were for

this and other reasons led to believe that the atom was built up of a number of positively charged units, each having a weight equal to that of the hydrogen atom, combined together. The positive charge in the atom was proportional to the number of these units and hence to the atomic weight. We knew, however, that the number of free electrons was not equal to the atomic weight but to the atomic number.

How, Sir Joseph continued, did the positive units stick together? It was not legitimate to suppose that the law of the forces between charges so closely adjacent was the same as when they were separated by considerable distances. Still, whatever the law governing it, the repulsion existed, and some sort of cement was required to keep the charges together, and this was provided by a certain number of electrons mixed up with the positively charged units. These had to be brought down to the centre of the atom from the exterior, thus reducing the number of free electrons below that of the positive charges.

A mathematical investigation of the conditions of the stability of such a nucleus was for the present almost impossible, but if we studied the list of the atomic weights certain rules were apparent. Confining attention to elements with atomic weights under 40, which were those most accurately known, it was to be noted that if the atomic weight were divided by 4, the residue was always either zero or 3. There were but two exceptions to this rule, viz.: beryllium, with an atomic weight of 9, and nitrogen, of which the atomic weight was 14. With numbers given at random there ought to be as many with one remainder as with any other, but the data showed that the elements could be divided into two types, with which the remainders, after dividing the atomic weights by 4, were zero and 3 respectively. This law would result if we supposed that the number of electrons going to produce stability of the nucleus must be an even number and at least one-half the number of positive charges they bound together. If we tried to build up the elements on this rule with one positive charge no electron cement was necessary, and we thus had hydrogen with one positive unit. With two positive units we should require by the proposed rule at least one-half the number of cementing electrons, but the half of two was an odd number, and we had, accordingly, no element of atomic weight 2. In the case of three nuclei we must have at least one-half the number of nuclear electrons; that was to say, in this case, two, which was an even number, and an element of atomic weight 3 was, therefore, possible. It would be remembered that in the course of his positive-ray analyses he had very frequently found particles with an apparent atomic weight of 3. It would, however, be very difficult to get chemical evidence of the existence of this body, since two of the positive charges were neutralised by the central electrons, and the electrical field produced would be indistinguishable from that of hydrogen. It was this field which determined the chemical properties of the atom, and hence an element of atomic weight 3 would be very elusive to chemical tests. Its constitution would be identical with that of hydrogen and, in fact, he had in the past considered his find as H_3. It would seem, however, that an element of this atomic weight might possibly exist, differing from hydrogen only in other than chemical properties. Coming to a nucleus of four, this, by the rule, would be stable with two nuclear electrons, as half of four was an even number. We had accordingly helium, which was known to have two free electrons. With five positive charges at the centre of the atom, the number of cementing electrons could not be three, as this was an odd number. Four was a possible number, but in that case the chemical properties would be identical with those of hydrogen, and such an element was not known to exist. With six positive charges we could not have three cementing electrons, since three was odd, and with four the element having but two free electrons would not be distinguishable chemically from helium. With seven, four cementing electrons would serve, and we got lithium. With eight, there was a gap, no element of this atomic weight being known, whilst beryllium, with atomic weight 9, should not exist. Nitrogen provided the only other anomaly. With ten we could not have five bonding electrons, as five was an odd number, and an element of atomic weight 10 was unknown. With eleven, we got six bound electrons and five free ones, corresponding to boron, and twelve positive units gave us carbon. Proceeding in this way it was possible to account for all the elements up to atomic weight 40, with the two exceptions already stated.

Above this limit the same principle could be applied, but more negative charges than one-half the total of positive ones were needed as cement. In fact, a discontinuity appeared with calcium, after which the positive charges required four more than half their number of electrons mixed with them to hold them together. Later on further critical stages became evident, at which the binding electrons had to be in still greater excess over the figure of one-half the positive units. The elements located where one flight ended and the next began had properties of an interesting character. There were long series throughout which the law governing the number of bonding electrons was constant, and then came points of discontinuity at which a fresh series commenced.

In work of this kind it was important to take the atomic weight as proportional to that of hydrogen. Chemists preferred to refer the atomic weights to oxygen, as being more convenient for their purposes. Taking hydrogen as the basis, it would be found that with very few exceptions the atomic weight was always less than the nearest whole number. To this rule silicon and chlorine provided the only exceptions. It was known that mass was not constant, but depended on the amount of energy represented. If we had systems built up with positive and negative particles which required a large amount of energy to pull apart, the mass of the system would not be the same as that of its constituents when separated from each other, but would be slightly more than in the latter case. In actual atoms the mass was slightly in defect. The amount of the change in mass could be calculated by the rule that if a mass equal to the missing quantity were set to move with the velocity of light the kinetic energy represented would be equal to the work required to bring the constituents of the atom together again. With the exception of silicon and chlorine, the mass of the atom was always just a little less than the sum of its constituents. This fact indicated that work must have been done in pushing the constituents together. The amount of this could be estimated by the difference between the atomic weight and the nearest whole number. The amount thus determined represented a greater amount of energy than had yet been found in the α particles emitted by radioactive bodies. There was thus a great store of energy in the interior of ordinary atoms.

The biggest discrepancy in the rule that atomic weights approximated to whole numbers was found in the case of chlorine, the atomic weight of which, referred to that of hydrogen, was 35.2. [Referred to oxygen as 16 it is 35.46.] If this figure could be relied on it would mean that no work had been expended in building up the chlorine atom. He was inclined to think, however, that the real reason for the difference between chlorine and other elements was that chlorine as we knew it was mixed up with molecules of another body with identical chemical properties, but of slightly greater atomic weight. If the true figure for chlorine was 35 there would be 18 inside electrons and 17 free electrons. An atom with atomic weight 39 and with 22 nuclear electrons would also have 17 free electrons and the same chemical properties as chlorine. The addition of 3 per cent. of such a body to true chlorine would account for the whole of the discrepancy. He hoped to attack this question by the positive-ray method of analysis, and to find out whether any evidence could be obtained of a chlorine with an atomic weight 4 units greater than that of ordinary chlorine.

GERMANY'S HOLD ON THE IRON ORE OF FRANCE.

(Concluded from page 541.)

THE German iron industry is not content with providing for its iron ore requirements for the hour and the day, but works with a view to the future. The only effective way in which this end can be attained is by becoming possessed of iron ore deposits, either through original concessions or by subsequent purchases. The French mining law of 1810, still in force, prevents foreigners from acquiring direct concessions, and without such no mining concern can be started. But some large German undertakings have, indirectly, succeeded in becoming possessed of French mines. They are: Röchling Brothers, the Phœnix, Haspe, Hoesch and Aumetz-Friede combine, the Gelsenkirchen concern, and the Thyssen concern.

Röchling Brothers, as already mentioned, control half of the Valleroy concession, and own in addition the Pulventeux concession (534 acres), situated in the district of Longwy. The ore from the Pulventeux mine is exclusively used by and smelted at the iron works of the above firm, about 100,000 tons annually. Röchling Brothers have formed a French company to work the mine, the original French company obtaining shares to the value of 500,000 francs.

The combine or syndicate of Phœnix, Haspe and Hoesch has, as mentioned, important parts in the Jarny and Sancy concessions, and the Lorraine iron works of Aumnetz-Friede in that of Murville. The four concerns have further clubbed together for joint action in connection with the Normandy mines and, with some capitalists in Caen, formed a financial group for opening out and working the concessions of St-André, Maltot and Bully, with an aggregate area of 2,790 acres. The particulars of the agreement are not known, so it cannot be stated whether the concessions have finally passed into the possession of the German syndicate or whether they are formally held by the French capitalists; in the latter case, which is considered the more probable, the German syndicate has a continuous contract for the whole production of the concessions. The main thing, naturally, is that the German iron works in question have secured the output of these mines, a fact which is all the more important for the works concerned on account of the high quality of the ore, the comparatively cheap transport by sea to Rotterdam, and the increasing difficulty of obtaining the necessary iron ore from other markets. The three concessions are situated in the vicinity of Caen, but the St-André concession is the only one which has, so far, been worked. This mining district has not yet been fully investigated, but there is reason to believe that the ore deposits extend further east. The high quality of the ore and the vicinity of the deposits to Caen make them very valuable. The St-André concession had been worked for some years by a French company in a very modest way, with an annual production of 28,000 tons, until, in 1910, the old company was dissolved. A new powerful company, the Société des Mines de St-André, was formed, in which the German firms referred to—and to which the German Luxemburg Mining Company may be added—were strongly represented, whilst the old company only contributed the concession and the plant. More energetic working at once commenced, and in 1913 the output had reached 51,236 tons; the production, however, can easily be increased to 100,000 tons annually or more. The concessions of Maltot and Bully belong to the same German group as St-André. They belonged to French capitalists, but were in 1911 transformed into two companies, in which German firms are represented. So far, only pioneer work has been undertaken in these two deposits, but they promise well.

The Gelsenkirchen Mining Company is one of the largest concerns in this branch. Rich as are its coal mines in Germany, the company's supply of iron ore, in spite of its concessions in Lorraine and Luxemburg, is somewhat precarious. It is therefore only natural that this large company should have exerted itself to become possessed of iron ore deposits abroad, in spite of geographical, political and technical difficulties, difficulties which had to be and which were overcome. The company has even secured the option of rich iron ore deposits in Sumatra from the Dutch Lampongsche Exploratie Maatschappi, and the Gelsenkirchen Company also belongs to that syndicate of German iron works which took steps to secure certain large Brazilian iron ore deposits, and for this purpose had arranged for a commission of experts of their own to go to Brazil. It goes without saying that a firm like the Gelsenkirchen has done all in its power to secure French iron ore concessions, which may not be so rich in iron as those just referred to, but, on the other hand, are located in convenient proximity to the company's iron works at Esch, and thus entail but slight expense for transport. The Gelsenkirchen Company controls in France about 4,900 acres of iron ore deposits, comprising the concessions of St-Pierremont, Sexey, Haute-Lay, St-Jean, Sainte-Barbe, Crusnes and Villerupt.

The St-Pierremont concession was originally granted to a French company, which in 1908 transferred it, through "portion shares," to the following iron works: the Société des Usines de l'Espérance, in Louvroil at Maubeuge (367 parts); the Société des Hauts-fourneaux de la Chiers, in Longwy (233 parts); the

Société Métallurgique d'Espérance-Longdoy, in Liége (367 parts); and the Gelsenkirchen Company (1,037 parts). This syndicate of iron works formed the Société des Mines de St-Pierremont, with a capital of 20,040,000 francs. Herr Kirdorf was elected president of the board, and the general director, Stellung, of the Gelsenkirchen Company also holds an important position in the concern. In the year 1911 the Gelsenkirchen Company increased its interest in the French company by buying the shares of the Société de la Chiers (except 30).

The St-Pierremont ore deposits were opened out in the year 1908, and the production has increased at a rapid rate; in 1910 the output exceeded 100,000 tons, and in 1913 it amounted to 860,200 tons; 1,000,000 tons would easily have been exceeded, had not the war arisen. This concession comprises 2,266 acres. The working conditions are fairly favourable, and there is direct railway connection. The Société des Mines de Sexey is owned by the same syndicate of iron works and in the same proportion as that of St-Pierremont. It was founded in 1906, and controls four concessions with an aggregate area of 2,192 acres in the Nancy district, viz., Haute-Lay, not yet opened out; Saint-Jean, with an annual production of about 100,000 tons; Sainte-Barbe and Sexey-aux-Forges, with a production of about 25,000 tons each. In addition the Gelsenkirchen Company, albeit in a different manner, has secured the possession of the mines of Crusnes and Villerupt, which were both owned by the Société Métallurgique d'Aubrives-Villerupt. Since 1909 the Gelsenkirchen Company has had the exclusive control of the iron works company of Aubrives-Villerupt. These mines are in the immediate vicinity of the immense Gelsenkirchen iron works at Esch, and the ore in question can be conveyed to these blast-furnaces at a trifling cost. Negotiations have of late years been pending between the Luxemburg Prince Henry Railway and the French East Railway Company about the construction and working of a direct line, Villerupt-Esch, which would have further facilitated the transport of ore. Up to the time of the war only the Villerupt deposits (803 acres) were being worked; the output in 1911 amounted to 194,000 tons. The working is both on the surface and underground. The Crusnes deposits (1,173 acres) have not yet been worked, and form a good reserve for later requirements of the Gelsenkirchen Company.

August Thyssen is the largest German owner of French mining property. His mines in Germany and Luxemburg cannot nearly adequately supply the requirements of his numerous iron works at Hamborn, Duisburg-Meiderich, Mühlheim and Hagendingen. The Thyssen concern has therefore, for a number of years, been on the lookout for foreign supplies, and has arranged for an extensive import of iron ore for the different works. Their agreement with Swedish iron ore concerns in Lapland, jointly with the Gutehoffnungshütte, the Schalke iron works, and the Rhenish steel works, expires this year. The agreement with the Russian Kolatchewski Company for 80,000,000 poods (1,300,000 tons) of ore is the largest contract of the kind so far concluded. From 1908 to 1912 the firm's imports of Russian iron ore to Ruhrort amounted to 3,200,000 tons. When the new ore deposits in France, first in the east and then in Normandy, began to attract attention, the Thyssen firm managed to secure their share. In the department Meurthe-en-Moselle Mr. Thyssen acquired the concessions of Batilly, Bouligny, and Jouaville, and in Normandy those of Perrières, Soumont and Diélette. The three Thyssen concessions in the minette district of eastern France comprise 5,313 acres. The concession of Batilly was granted to him direct, which was only possible in the early days of this mining industry, when public opinion had not yet realised the German invasion. This condition, however, did not continue long, and Thyssen is the only officially German mining concessionaire in France. Direct mining concessions in France to foreigners have since been prohibited. The concession of Jouaville was ceded to Thyssen by the Société des Hauts-fourneaux de Saulnes, and he then founded a French company, the Société des Mines de Jouaville, with a capital of 2,000,000 francs; the vendor obtained some shares in payment, Thyssen keeping the rest through his representative. The method used for the acquirement of the Bouligny concession was similar to that the Gelsenkirchen Company employed in the case of the Villerupt and Cuisnes deposits. The Bouligny concession belonged originally to someone from Meurthe-et-Moselle, who for 4,800 shares ceded it to the Société des Mines de Bouligny. This company, however, formed at the end of 1906 with a capital of 3,500,000 francs, was a French *pro forma* company, affiliated to the Belgian Société Métallurgique de Sambre et Moselle, which since 1904 has been under the control of Thyssen, who through the medium of the Belgian company became the indirect owner of the Bouligny concession. The concessions of Batilly and Jouaville are not opened out yet, but their prompt working has been decided upon and a rope railway planned from the mines to the Thyssen iron works at Hagendingen.

As regards the Normandy deposits, Thyssen was on the alert whilst French iron-masters and capitalists were still shrugging their shoulders, indisposed to treat the news of these valuable ore deposits seriously. In the year 1900 a French engineer examined the locality. Thyssen's attention was thus drawn to the Perrières deposits, which he, after a thorough investigation, acquired. Then he caused his engineers to examine the whole district, and he secured the concessions of Soumont and Délette. These three concessions represent an area of 6,375 acres, or one-sixth of the whole of the Normandy mining district.

In 1901 a company was formed for the working of the Perrières deposits, the Société Minière et Métallurgique du Calvados, with a capital of 1,200,000 francs, in which Thyssen was much interested, as well as in the Société Générale pour Favoriser le Développement du Commerce et de l'Industrie en France. Up to the time of the war a great deal of preparatory work had been done, four shafts had been sunk, and numerous borings undertaken; everything was, in fact, almost ready to start working in earnest, excepting the transport of the ore, which difficulty, however, soon would have been overcome by the construction of the railway from Perrières and Soumont to the blast-furnaces and steel works at Caen. The concession of Soumont (1,910 acres) adjoins that of Perrières, and had been given to someone at Caen, who was anxious to start work at once, but lacked the necessary capital. The whole matter was on the point of being dropped, no money being obtainable in France, when a middleman laid it before Thyssen, who had shortly before secured the Perrières concession, and who, in 1907, formed the Société des Mines de Soumont, with a capital of 2,000,000 francs, the vendors receiving 500,000 francs in shares, most of the rest going to Thyssen's representative. Thyssen at once started work. The next year some 8,000 tons of ore were broken, the output having risen to 69,984 tons in 1912. The ore is sent via Caen and Rotterdam to Germany, pending the completion of the Thyssen blast-furnaces at Caen, which are to be, or were meant to be, supplied with the ore from the two last-mentioned concessions, a consumption of some 500,000 tons then being reckoned upon.

Thyssen had barely secured the Soumont concession before the Diélette deposits were offered to him. They are situated in the outer angle of the Manche department, some 25 km. from Cherbourg, and have the peculiar feature that they are mostly worked under the sea. The deposits had been known for a long time, and had been subjected to various vicissitudes. The working under the sea was difficult and almost impossible without adequate plant, in which respect the French were somewhat unfavourably situated. Flooding occurred in the only shaft; vessels could not enter the small harbour of Diélette, so that the export of ore was impossible. Several companies came to grief, when at last a Paris contractor, who had bought the mine, offered it to Thyssen, who in 1907, started the Société des Mines at Carrières de Flamanville, with a capital of 360,000 francs, most of which Thyssen secured. Work was at once commenced; new shafts were sunk and protected against the influx of water, a harbour was constructed 600 m. from the shore capable of accommodating vessels of 1,500 to 2,000 tons, and the pit was connected with the harbour by means of a rope railway. The preparatory works at Diélette entailed an expenditure of about 10,000,000 francs, but the ore deposits have proved richer than expected and are estimated to contain 70,000,000 tons. In addition, the quality of the ore is good, as will appear from the appended analysis:—

Fe	57.36
Mn...	0.07
P	0.24
SiO_2	11.87

It will appear from the particulars given above that Germany, in addition to an annually increasing import of French iron ore, at the beginning of the war possessed about 29,654 acres of iron ore deposits in France, besides being considerably interested in a further 16,557 acres of iron ore deposits. These figures at the same time illustrate Germany's great and increasing want of iron ore and the enterprise shown by the German iron-masters to secure suitable deposits abroad.

Germany is interested not only in iron ore deposits, but in the French iron industry, since it is sometimes more advantageous to exploit the ore on the spot. The two German concerns principally engaged in the French iron industry are the two large firms already mentioned, the Gelsenkirchen Company and August Thyssen, through their respective undertakings, the Société d'Aubrives-Villerupt in Longwy, and the Société des Hauts-fourneaux et Aciéries de Caen, in Normandy.

In the year 1858 works were started at Aubrives for the manufacture of cast-iron pipes, and in 1889 these were transformed into the Société d'Aubrives. This company owned no iron ore deposits, and the prospects were not promising, when an arrangement was arrived at with the Compagnie des Forges de Châtillon-Commentry et Neuves Maisons. In 1894 a company, the Société Métallurgique d'Aubrives-Villerupt, was formed in Paris, with a capital of 4,250,000 francs, which absorbed the last-mentioned two concerns. The new company thus became possessed of iron works and some contracts for iron ore production remaining in force till the year 1943. The company extended its plant, but there appeared serious difficulties in obtaining the necessary capital in France, where foreign investments, for many years, were preferred to home undertakings. The Société Générale de Belgique, however, came to the rescue and took over the majority of the shares, the capital in the meantime having been raised to 6,750,000 francs. As no dividend was paid the first few years, the shares fell considerably below par, and the Belgium Bank was only too pleased to receive an offer at par from the Gelsenkirchen Company, which had become acquainted with the position of affairs. As soon as the Société d'Aubrives-Villerupt had passed into the possession of the Gelsenkirchen Company, the whole undertaking was at once Germanised, and the new owner secured the possession of the plant and iron ore concessions, which had so far only been rented, at an outlay of 3,000,000 francs. In 1911 a further sum of 3,000,000 francs was expended, the money, strange to say, being found by French capitalists, who had gained confidence in the German management, and it has turned out a good business for the Gelsenkirchen Company.

Whilst August Thyssen could locate the iron and steel works for his ore deposits in Eastern France, in Batilly, Bouligny and Jouaville, and on German soil at Hagendingen, on the French frontier, it became necessary to handle the ore from his deposits at Perrières, Soumont and Diélette in Normandy, within France, near the mines, and with a good connection with the world's market. In spite of many difficulties, Herr Thyssen succeeded in realising his plan in a comparatively short time. At the general meeting of the company in 1914 he announced that the completion of the large iron works in France was in sight and that work would commence early in 1915. A kind of provisional company was started in 1910, the Société des Hauts-fourneaux de Caen, with a capital of only 500,000 francs, of which Thyssen subscribed four-fifths, the balance being taken up by a friend of his in Paris. First of all means of transport had to be provided from the Perrières and Soumont mines to Caen, but the council of Calvados refused to grant the necessary permission. The following year, however, an arrangement was arrived at, the Caen Chamber of Commerce being strongly in favour of Thyssen's large scheme being realised. In 1912 a ministerial decree declared the railway for the transport of ore from the above mines to the railway station and harbour of Caen a public undertaking, and this carried the official sanction of Thyssen's venture in Normandy. The first company was promptly transformed into the Société des Hauts-Fourneaux et Aciéries de Caen, and the capital was raised from 500,000 francs to 30,000,000 francs.

The French Government, however, insisted upon the following guarantees to ensure the company being a French concern, the foreign interest being in the minority:—

1. The undertaking shall comprise three separate companies:—(*a*) The iron works at Colombelles, Caen, which constitutes the principal company; (*b*) a mining company, with the concession of Perrières and Soumont; (*c*) a harbour company, for the construction and working of the harbour at Colombelles. The iron works company to form the other two companies, and Thyssen's share in the capital of these two companies must not exceed 40 per cent., the ironworks company to find the 60 per cent.

2. The board of the three companies must consist of four French and three foreign members.

The ironworks company, which takes precedence of the two other companies, shall in its turn act under the Société de Cail, and Thyssen's personal share must not exceed 40 per cent. of the total, the rest being taken up by the Société de Cail and a syndicate formed by the Comptoir National d'Escompte.

It will appear from this that the control, on paper at least, was not to be vested in Thyssen, but as he has planned the whole scheme and superintended the construction of the plant, and on account of his business ability and integrity, he would all the same be the actual head of the concern. In addition Thyssen was, in reality, the stronger party financially. The shares were taken up by (*a*) Thyssen, (*b*) the Cail concern, and (*c*) the above-mentioned French syndicates. Thyssen had 44,000 out of 120,000 shares, the Cail concern (the Société Française de Construction Méchaniques), which, in addition to Thyssen, was also

interested in the first small company, had 43,800 shares, and the French syndicate held the balance. Most of the shareholders under this head were no doubt French, but it will be found that so far as the larger items of shares are concerned German interests are again to the fore, owing to Germany's extensive interest in French banking, and by the shares of these banks Thyssen's industrial position is very materially strengthened; of such banks may be mentioned the Banque Continentale de Paris, founded in 1910 by Littmann and Mayer, and in which the banking firm of Behrens in Hamburg is strongly interested; Allard and Company, with pronounced German interests, and the representatives of the Deutsche Bank; Langthaler and Schneider, leaders of the Paris branch of the German Länderbank.

The plan of the iron works at Caen comprises the erection of eight blast-furnaces with a daily capacity each of 400 tons and fitted with the most modern plant; the rolling mills and steel works are calculated to turn out 250,000 tons of finished products (plates, rails, girders) in the year. The coking plant will supply all the coke needed for the blast-furnaces and other purposes, and the auxiliary products will be duly utilised, as will the gas; in short, the Caen iron works will be equal in all respects to Thyssen's famous works at Hagendinger in Lorraine. The concern covers some 1,000 acres; as mentioned, it was to have been ready by the end of 1914, and operations were to have commenced in the beginning of 1915, with 7,000 hands.

The mines of Soumont and Perrières have been turned into one concern, with a calculated annual production of 1,000,000 tons; of this output 400,000 tons were to have gone to the Thyssen works at Ruhrort, by way of Rotterdam, and the balance to Caen. So as to extend the iron ore deposits, exploratory work has been carried on in Brittany and Normandy; in the former place with some satisfactory results.

Financially, the Caen concern, having a capital of 36,000,000 francs (30,000,000 francs of shares and 6,000,000 francs of debentures), has the largest capital of any undertaking in the French iron industry; thus the Aciéries de Longwy, with eight blast-furnaces, has a capital of 24,000,000 francs; the Micheville works, with six blast-furnaces, has a capital of 17,000,000 francs, and the Aciéries de la Marine et d'Homécourt, with seven blast furnaces, has a capital of 28,000,000 francs.

As M. Bruneau has remarked, "It would not become us to complain about a German having founded this giant concern on French soil, for we have not willed it otherwise. We alone are to blame."

STANDARDISATION OF COPPER TUBES FOR AIRCRAFT.

DIFFICULTIES having been experienced by aircraft contractors in obtaining supplies of copper tubing, the causes were investigated, and they were found to be (1) the great variety of sizes called for and (2) the fact that tube makers received orders very irregularly and for small quantities.

Arising out of the investigation, the specification committee of the Air Board has decided that in future copper tube for aircraft contracts will be specified in terms of external diameter and legal standard wire gauge. As far as possible tubes of 20 gauge (0.036 in.) will be used, to the exclusion of all other thicknesses. Where for special considerations it is desirable to use other thicknesses the choice will, as far as possible, be restricted to gauges 16, 18 and 22. The last-named is difficult to manufacture and will be avoided as far as possible. A new Air Board specification for copper tube will shortly be issued, and will have as an appendix the following list of sizes and gauges which the Air Board regard as standard:—

20 *Gauge*:—
$\frac{1}{16}$ in., $\frac{1}{4}$ in., $\frac{5}{16}$ in., $\frac{3}{8}$ in., $\frac{7}{16}$ in., $\frac{1}{2}$ in., $\frac{5}{8}$ in., $\frac{3}{4}$ in., $\frac{7}{8}$ in., 1 in., $1\frac{1}{8}$ in., $1\frac{1}{4}$ in., $1\frac{3}{8}$ in., $1\frac{1}{2}$ in., $1\frac{5}{8}$ in., $1\frac{3}{4}$ in., 2 in.

18 *Gauge*:—
1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in., 2 in.

16 *Gauge*:—
$\frac{1}{2}$ in., $\frac{5}{8}$ in., $\frac{3}{4}$ in., $\frac{7}{8}$ in., 1 in., $1\frac{1}{4}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in., 2 in., $2\frac{1}{4}$ in.

22 *Gauge*:—
1 in., $1\frac{1}{8}$ in., $1\frac{1}{4}$ in., $1\frac{3}{8}$ in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in., 2 in.

REFRACTORY MATERIALS.*

THE Committee are glad to report that during the past year the provision of the necessary apparatus at the County Pottery Laboratory, Stoke-on-Trent, under Dr. Mellor, has made considerable progress, in spite of difficulties in obtaining delivery of apparatus. The necessary plant for the investigation of the question of refractoriness of material under load, and of the differences in size of bricks when cold and when at high temperature, has been completed for some time, and research in these respects commenced. The apparatus for investigating the influence of fine flue dust carried into the setting on the refractoriness and life of the materials employed is now also practically complete.

In previous years the work done has been chiefly carried out on manufactured materials obtained from different makers or on material taken from deliveries to different gas works. As stated in last year's report, it had been found essential to employ in the work, in addition to such material, bricks which had been manufactured from known materials and under exactly defined conditions, and Dr. Mellor had been authorised to arrange for the manufacture of such bricks. A large quantity of clay, amounting to about 20 tons, has been obtained from six sources, representative of the different varieties of material found in the United Kingdom, and has nearly all been made into bricks for testing purposes. The method of manufacture has been varied for the different qualities of clay, both in respect to the quantity, fineness, and firing temperature of the grog, and in the firing temperature of the finished brick. The bricks, thus made in such a manner that their "life-history" is known, will be employed by Dr. Mellor in the various researches now in progress.

Sets of 100 of different kinds of bricks are also being fired in industrial furnaces at about 1,300 deg. C., five of which are removed after each firing (extending over eight days). When the 20 firings are completed the bricks will all be examined to observe deterioration according to the length of time of firing.

The hot to cold measurements of the bricks collected as typical of those on the market are completed, and the results obtained are given in detail in the report of Dr. Mellor. The results obtained are such as to cast some doubt on previous measurements of the coefficient of thermal expansion of firebricks and related materials at high temperatures, as the true thermal expansion is obscured by effects due to the after-expansion or after-contraction of the firebrick which is taking place while the bricks are being measured. The work carried out by Dr. Mellor in this respect demonstrates the importance of taking into account the continued alteration in the character of bricks under prolonged or repeated heating.

A number of measurements of the after-contraction or expansion of firebricks have been made to test the conditions laid down in this respect in the standard specification, and the results obtained are given in Dr. Mellor's report. The general conclusion derived from this series of tests is that the tendency is for ordinary silica bricks to give a less expansion, and firebricks of fireclay to give a greater contraction in the reducing than in the oxidizing atmosphere.

The tests on the refractoriness of whole bricks under load are not yet completed. Quite a number of unforeseen difficulties have arisen and been overcome. Dr. Mellor has had to investigate the difference in temperature between the interior of the brick and the outside when the softening temperature is actually determined, and in order to ensure that the interior and exterior shall be at one uniform temperature in a reasonable time—3 to 5 hours—test pieces of about 3 in. by 3 in. appear to be most suitable. If the test pieces are 1 in. by 1 in. or less their preparation interferes with the structure, and fallacious results are obtained under load. Two large pieces of grog, for example, side by side would produce a weak spot which would break down far below that temperature which is a true characteristic of the brick. Unfortunately difficulties increase as the size of the test piece increases. These tests are being continued with the bricks which have been specially manufactured under known conditions, as well as with standard bricks on the market.

Apparatus has also been ordered for the investigation of the effect of a reducing atmosphere on refractoriness, but this has not yet been delivered.

The question of modifications of the standard specification has been further considered, but it was felt that under existing conditions it would be inopportune to make any material changes in the tests specified; two alterations have, however, been made in the specification relating to retort material. The wording of the specification relating to the material to be employed in the manufacture of retorts might be taken to preclude the admixture of silica material with the fireclay used for retort manufacture. To prevent any misconception on this point words have been added permitting the use of silica material, and Clause 1 now reads as follows:—The retorts or retort tiles shall be made of sufficiently seasoned raw clay compounded with clean burnt clay or grog; they may also be made from suitable silica material. No "grog" shall be used which will pass through a test sieve having 16 meshes to the linear inch.

Further, although in the standard specification it is laid down that the porosity of the retort material should be 18 per cent. as a minimum, no maximum porosity is specified, as at the time the specification was drawn up no sufficient data were available for fixing such a maximum. In view of the experience gained since then it has now been agreed that, in addition to a minimum porosity of 18 per cent., a maximum porosity of 30 per cent. shall now be specified.

With respect to the expenditure of the committee, it will be seen that the cost of the apparatus ordered during 1916 would have exceeded the funds at their disposal, but for the fact that, owing to late delivery of the apparatus, some of the accounts did not become due for payment until after the financial year had closed, and allowance has to be made for the payment of this surplus during the current year. For this year the Institution and the Society of British Gas Industries have each increased their grant for 1917 from 50*l.* to 150*l.* Application has also been made to the Advisory Committee of the Privy Council for Scientific and Industrial Research to increase their grant for 1917 from 130*l.* to 300*l.*, and the Institution has now been officially informed that this application is granted. The increased sum thus available will enable the committee to expend a larger sum in the payment of qualified men to act as whole-time assistants under Dr. Mellor to carry on the necessarily lengthy and detailed tests. Last December, as soon as the necessary apparatus was sufficiently advanced to permit of further work, an assistant was appointed for this work, and additional assistance will be provided as the conditions enable this to be done with advantage, if suitable qualified men can be obtained, a matter not at all certain under present conditions.

During the last year a number of developments have taken place in connection with the subject of refractory materials, and the requirements of the whole of the industries of the United Kingdom in this respect. At the end of the year a "Refractory Materials Section" of the Ceramic Society was instituted to form a technical society for dealing with matters relating to the manufacture and development of refractory goods. The membership of this section is open to users as well as manufacturers, and meetings of the section will be held twice a year at different centres.

A general discussion on the subject of refractory materials was organised in London last autumn by the Faraday Society, and following on that discussion, at the instance of the Iron and Steel Institute, a meeting was arranged of delegates of a large number of technical societies to consider what steps might be taken towards the co-ordination of research work on refractories and to endeavour, if it seemed desirable, to secure joint action in carrying further the work of standardisation. The council of the Institution appointed the chairman and vice-chairman of the Refractory Materials Committee as delegates to this conference, which was held on March 22. After a general discussion of the subject a sub-committee was appointed of the following members: Mr. A. Cliff, Professor J. W. Cobb, Dr. R. T. Glazebrook, F.R.S., Sir R. Hadfield, F.R.S., Mr. Cosmo Johns, Dr. J. W. Mellor, and Dr. A. Strahan, with Mr. F. S. Spiers as secretary.

* Report of the Refractory Materials Committee of the Institution of Gas Engineers presented June 5, 1917.

COLONIAL ENGINEERING PROJECTS.

WE give below a few data on Colonial engineering projects, taken from *The Board of Trade Journal*. Further information can be obtained from the Department of Commercial Intelligence, 73, Basinghall-street, E.C. 2.

Newfoundland.—H.M. Trade Commissioner in New Zealand calls attention to notices published in the issues of the official *New Zealand Gazette*, to the effect that the Borough Councils of Lyttelton and Wairoa have been authorised to erect and maintain electric transmission lines for lighting, power and heating purposes within the boroughs of Lyttleton and Wairoa.

Australia.—The *Government Gazette of Western Australia* publishes a notice to the effect that the Minister of Water Supply has authorised the construction in the Bridgetown area of a reservoir, and the laying of a cast-iron gravitation main with valves, hydrants and all necessary apparatus, for the purpose of providing a water supply for the Railway Department.

CHARCOAL FOR HIGH EVACUATION.—The use of charcoal in connection with the study of vacuum-tube phenomena has become so general that attention may be drawn to a paper by Harvey B. Lemon, presented to the American Physical Society in their Chicago meeting, December, 1916. The cocoanut shell is generally carbonised at a temperature ranging from 825 deg. to 875 deg. C. Great care should be observed not to let the temperature rise too high in successive heatings, as that may spoil a charcoal, whilst with judicious treatment a charcoal will improve very much by being reheated for expelling the gas absorbed. On the other hand, five minutes' pumping at a certain temperature may drive out more gas than five hours' pumping at a temperature 30 deg. lower. Each gas has its own temperature at which it is abundantly liberated. Nitrogen comes off freely at 150 deg. C.; the rush of oxygen sets in at 300 deg. and becomes particularly noticeable at 600 deg. C.; hydrogen is hardly liberated below 750 deg.

MANGANESE-GOLD ALLOYS.—Roberts-Austen and Osmond studied alloys of Mn and Au, but did not determine the diagram. In their experiments L. Hahn and S. Kyropoulos (*Zeitschrift Anorgan. Chemie*, vol. xiv, page 105, 1916) fused the two metals as quickly as possible at 1,300 deg. C. in porcelain tubes, because the manganese attacks the porcelain and is oxidised, and determined the cooling curve. This curve shows a maximum at 50 per cent. Au, and two minima at 32.5 per cent. and 77.5 per cent. Au (all atomic percentages), the corresponding temperatures being, roughly, 1,200 deg., 1,050 deg. and 950 deg. C. There were dendritic crystals of AuMn, surrounded by polyhedric crystals of alloys richer in gold and increasing in size with the gold percentages. Treatment with acids (acetic or nitric) shows, however, that the manganese is more concentrated in the centre of the dendritic crystals than near their circumference. The rate of diffusion of gold in the rich Mn alloys is very slow at 1,000 deg., but could not be accurately determined, because the Mn was oxidised and volatilised. Up to 62.5 per cent. Au the alloys are grey, becoming yellow with higher gold percentage; they were very brittle up to 55 per cent. of gold; alloys of more than 62.5 Au could be forged and cut with the saw. Pure manganese is not easily obtained; the manganese of the experimenters contained 5 per cent. of aluminium. The authors do not agree with Parravano as to the alloys rich in manganese (*Gazzetta Chimica*, 1915, I).

DRAUGHTSMEN AND FOREMEN.

TO THE EDITOR OF ENGINEERING.

SIR,—The recent correspondence in your journal in regard to the A.E.S.D. is no doubt of considerable interest.

I see no reason why we should not aspire to the standard of any existing profession, and although the time is probably not opportune to impose an examination on members, such a course at a later date might be of considerable advantage both to employer and employee.

A sea-going engineer must possess a Board of Trade certificate, and such a document in the hands of the draughtsman would safeguard him from unjust criticism, founded on personal opinions. The employer would also have an indisputable guarantee of the man's qualifications.

Men have no right to demand more than justice, which largely means equality of opportunity, to obtain which, if a man be qualified, should not involve years of wasted energy overcoming unnecessary obstacles.

Yours respectfully,
A DRAUGHTSMAN.

TO THE EDITOR OF ENGINEERING.

SIR,—I should be pleased if you would kindly publish the following reply to your correspondent who signs himself "Staff," and whose letter appeared on page 553 of your last issue. My letter of the 1st inst. did not refer to his first letter, and he is wrong in thinking that I implied that his letter gave support to the oft-quoted statement that draughtsman's work is unproductive. What part of my letter did was to point out that your correspondent of the 25th ult., who is an official of the Association of Engineering and Shipbuilding Draughtsmen, gave support to this statement.

In the other part of my letter I pointed out that it is futile to make comparisons with professions where an examination is a *sine qua non* until draughtsmen have some standard of qualification.

Your correspondent "Staff" put the blame on the Government education policy. This has not prevented other societies from having an entrance examination. He also points out that the policy of the Association of Engineering and Shipbuilding Draughtsmen is to foster an entrance examination. This is, unfortunately, not my personal experience. He further says that the time is too critical to bring into practice this policy. With this I do not agree. The postponement of this policy to the dim future means that a greater number of unqualified men will have to be taken in.

In view of this, it would assist materially in raising the status of designers or draughtsmen if men of the necessary qualifications would come together to discuss a standard and form a society.

Yours sincerely,
HAROLD C. CLAUSEN.

5, Leighton Buildings, Westminster, London, S.W. 1,
June 11, 1917.

THE METRIC SYSTEM.

TO THE EDITOR OF ENGINEERING.

SIR,—Every metrist should thank Mr. Halsey for confounding our enemies with a clearly worded statement that proves that which we have asserted for years, *i.e.*, that English and American tools, made to inch measurements, are quite acceptable to M. Benet and other metric users.

Yet before he finishes his letter the old myth comes up fresh as ever, and the heads of two great firms are made to tell the cost of the change (of machinery) which he has just proved to be unnecessary as far as the continued use of present plant to execute metric work is concerned.

Yours truly,
EDWARD C. BARTON.

TO THE EDITOR OF ENGINEERING.

SIR,—There are many objections to the metric system, and the advocates of the combined metric and decimal systems cannot succeed in their demands until they overcome those objections. Let me run through some of them.

1. The claim to "absolutism." There is nothing particularly meritable in the metre being the one ten-millionth part of the quadrant of the earth. This does not make the metre a "natural" unit. As it is the relation is incorrect. Also the litre and the cubic decimetre are *by international agreement* and *by law* not identical. Hence the whole claim that there is a watery relationship between metric weights and measures is absurd. There is none.

2. The above systems would get more supporters if they were consistent, but they sneak around for the worst parts of other systems and attempt to replace them, but fail to tackle the best parts of the older systems, or we might get the following tables :—

10 seconds = 1 minute.
10 minutes = 1 hour.
10 hours = 1 day.
10 days = 1 week.
10 weeks = 1 month.
10 months = 1 year.

Luckily, the sun and the moon and the earth were invented before the metre. Again :—

10 seconds of angle = 1 minute.
10 minutes = 1 degree.
10 degrees = 1 whole angle.

And where will the astronomers be ?

They might go on and decide that π and e shall both be unity or 10, and that railway stations should be a kilometre apart and the populations of all towns a multiple of 10. The world was not made so. Again, take the coinage. The decimalists of America having discarded pounds, shillings and pence, fixed on the dollar as a unit, and then took a half of a half of this for their commonest coin. What place has the "quarter" in a decimal system ?

3. The nomenclature of the metric system is abominable. The metricists condemn the English system because of its scruples, which the mass of the people rarely use, and then they go and invent myriametres and hectograms, which are nightmares. And who is to decide whether the "kilo." is a kilogram or a kilometre, or a kilo-something-else.

Compare the long four or five-syllabled words of the new system with the short English words pound, foot, inch, ton, peck, &c. How does the Shakespearean line "Every inch a king" sound in the decimal notation, "Every centimetre a president," and what about Shylock's "Kilogram of flesh ?" We can well imagine Portia shuddering at the thought of it.

4. It has been said that the electrical engineers employ the metric system, and that as they are all-powerful we must make way for them. But to my mind the ampere, volt, ohm and their derived units are not metric any more than they are arbitrary. Those who do not believe this may read the report of the International Conference on Electrical Units and Standards held in London in 1908. Even if they were metric, what shall we say about the kilowatt-hour or kilowatt-year, and does anyone attempt to replace these. As a teacher of a few years' standing I can see that in scientific work where we are making measurements, some of them being very small, the decimal system has the advantage, but in the practical work of manufacture I do not see that the metric system has any advantage over the English system. It is as easy to make half-inch and inch steel rods as 5 mm. and 1 cm. rods, or to cast pound weights as half-kilograms. And as far as buying and selling is concerned, who worries about calculations in these days of "ready reckoners" and "calculating machines" of all kinds ?

I, for one, have no quarrel with the supporters of English units. They are easy to those who have been brought up with them, and why worry about the foreigner who hasn't got the brains to understand them. Let's level up rather than level down.

By-the-by, some talk of the hardships on our children who have to work out myriads of sums based on the English system of units. That drudgery is the fault of the teaching (?) profession, not that of the system. Ninety-nine per cent. of the problems set children are sheer unmitigated nonsense. They have not even the remotest semblance to anything in actual life. Pedagogues go out of their way to set these useless problems, and then damn the English systems instead of their own eternal idiocy.

I am, sir, yours truly,
Toronto, May 31, 1917. JOHN SATTERLY.

PATENTEES AND THE PROLONGATION OF PATENTS.

TO THE EDITOR OF ENGINEERING.

SIR,—It was with some surprise that I read the correspondence in ENGINEERING of June 3 under this heading. My surprise was occasioned by the fact that I myself had been considering a letter to ENGINEERING on this identical subject for some eighteen months to two years past; but heavy pressure of war work always intervened to postpone the communication.

Briefly, my own case (which is probably the predicament of many others) is as follows: In the year 1914 I applied for and obtained two British patents in connection with motor cycles and internal-combustion engines for same. A third patent in the same connection was applied for and obtained in 1915. These patents were all eminently practical and would have had an appreciable sale.

The course and development of the war, however, has brought about many totally undreamed-of factors, which have entirely revolutionised the industrial world. That mysterious, little-understood, but, nevertheless, all-powerful weapon, the "Defence of the Realm Act," has been wielded so effectually by the Government as utterly to stamp out of existence many erstwhile large industries, of which the manufacture of motor cars and motor cycles (other than war machines) may be cited as two examples; consequently all patents in connection with the manufacture of pleasure cars and cycles are, at the present time and for the duration of the war, stamped out of existence also as regards their commercial value. Nevertheless, on patents of over four years' standing the Government are collecting their taxes as usual; taxes collected on property the Government have themselves rendered valueless.

Of course a patentee can neglect to pay the taxes, with the inevitable result of losing his patent rights.

The writer's contention is, that as the Government have purposely and knowingly effectually rendered these patents valueless (whilst at the same time not forgetting to collect the taxes), we think that the very least they (the Government) can do is to extend the length of every patent *adversely affected by the war* by the number of years the war shall last. That is to say, that should this unfortunate war continue to drag its weary length over still another three years (making six years in all, a by no means unlikely contingency, unless an active peace propaganda is instituted by the masses in this country, as at present in Russia), the Government shall not count those six years in the life of the patent, but shall reckon the balance of the fourteen years' term to date from August 4, 1914 (the date of declaration of war by the British Government), the scale of taxation to remain the same as in pre-war days. This, of course, to apply to such patents as can be proved to the satisfaction of the authorities *to have been adversely affected by the war*; some patents, naturally, will have reaped rich rewards during the period of hostilities, where those patents relate to armament, such as the Lewis gun, and similar war material used in great quantities by all the belligerents.

In the tremendous industrial upheaval and fearful commercial struggle which will ensue just as surely after this war as it has after every war in the history of mankind, we shall need all the scanty help the Government will grudgingly give us if we are even to hold our heads above water in the grim struggle for the world's trade, with dogged Germany as stubborn an opponent in trade as in war. Also let us not forget American competition, perhaps a far greater menace (should the old system of "free trade" be returned to) than that of our Continental neighbours, both enemy and ally.

A further injustice and hardship is being ladled out to inventors during the war, and that is, that no article can be patented *outside Great Britain* that can, in even the remotest manner, be used for war purposes. Consequently, should a man invent some great improvement in aeroplanes, submarines, guns, mines, or any paraphernalia used in warfare, unless the British Government condescend to utilise it, foreign Governments are closed to him under pain of death, even should that Government be a neutral. Inventors were always a hardly used tribe, but their position and prospects during the war are distinctly humorous—playing a barrel-organ outside a corner "pub," would prove a far more lucrative occupation.

Yours truly,
E. V. HAMMOND, M.E.,

88, Louisville-road, Balham, London, S.W.

FANS AND CENTRIFUGAL PUMPS.

TO THE EDITOR OF ENGINEERING.

SIR,—I should like to thank Mr. Price very cordially for his historical references to the mathematical treatment of the theory of fans given in his letter on page 553 of your last issue. He brings new facts to bear in a very apposite manner on an interesting point. I hope I may still consider that Mr. Innes' treatment was independent, though not original.

I do not follow Mr. Price so readily in his last paragraph. If I understand him aright, he demonstrates once more that it is always possible to find a flaw in either analogy or antithesis.

Yours very truly,
THE WRITER OF THE REVIEW.

June 9, 1917.

INDUSTRIAL FATIGUE.—A series of articles on industrial fatigue, from the pen of Professor Henry J. Spooner, recently appeared in *Co-partnership*. They have now been republished, with forewords from Sir Robert A. Hadfield, F.R.S., and Mr. J. R. Clynes, M.P., the one representative of enlightened capital, and the other of intelligent labour. The articles are not long—they cover about 50 small pages—but they give in a concise form pretty much all that is known on the relation of industrial fatigue to maximum output. There is no doubt that our munition workers could have turned out equal quantities if they had worked less overtime, and that many a strike has had its foundation in sheer fatigue and an overpowering desire for rest and change rather than in grievances. Gradually matters are mending, but we have to consider the future, and have to equate the necessity for an increased output against labour's desire for more leisure. One step towards this is a scientific investigation into the physiology of fatigue and recuperation, and every attempt to further this is to be welcomed. Professor Spooner's articles are republished by Co-partnership Publishers, Limited, 6, Bloomsbury-square, W.C. 1, price 6*d.* net.

THE YEAR BOOK OF WIRELESS TELEGRAPHY AND TELEPHONY.—We have received from the Wireless Press, Limited, of Marconi House, Strand, W.C., the fifth annual issue of this year book. It is a volume of more than 900 pages and covers an immense field. In the reference section is a "Record of the Development of Wireless Telegraphy" which gives a chronology of discovery and development from 1831 to 1914. All the laws and international conventions regulating wireless telegraphy are given in full, together with lists of land and ship stations, with every particular relating to them. In the technical section there are articles on "Time and Weather Signals," and a number of useful data and formulas by Dr. J. Erskine Murray. These are followed by definitions of terms and a polyglot dictionary of such words as are peculiar to wireless telegraphy. Among the special contributions is a summary of Judge Mayer's patent decision on the subject of the Fleming valve and the De Forest audion. Dr. Fleming writes on "The Electric Arc as a Generator of Persistent Oscillations." Dr. Eccles deals with the burning question of "Ionic Valves." Amongst the other technical articles we find one on the "Inductance, Capacity and Natural Frequency of Aerials," by Professor G. W. O. Howe; whilst Dr. E. W. Marchant gives a summary of the phenomena and principles which form the basis of the theory known as that of the "Heaviside Layer." The "Leading Features of American Long-Distance Stations" constitute the subject of a paper contributed by Mr. C. H. Taylor. Any reader, however slightly equipped with technical knowledge, may gather an excellent idea of these wonderful examples of modern electrical engineering from his lucid exposition. The price of the volume is 3*s.* 6*d.* net.

CONTROL GEAR FOR AUXILIARY ELECTRIC MOTORS FOR ROLLING MILLS.

CONSTRUCTED BY THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, ENGINEERS, RUGBY.

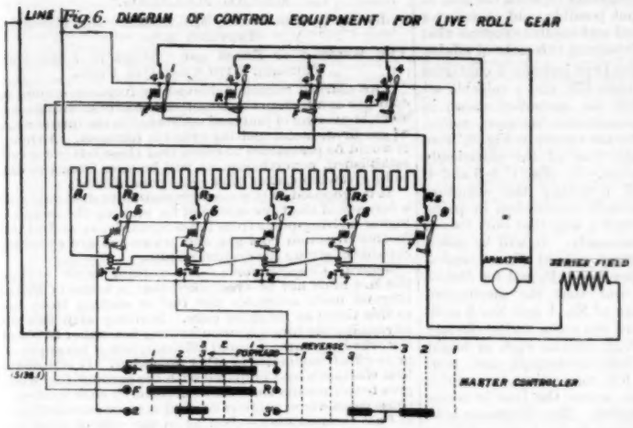

Fig. 6. DIAGRAM OF CONTROL EQUIPMENT FOR LIVE ROLL GEAR

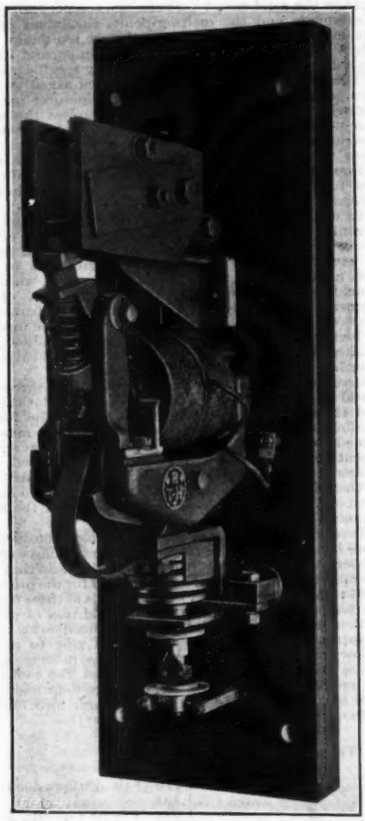

FIG. 9.

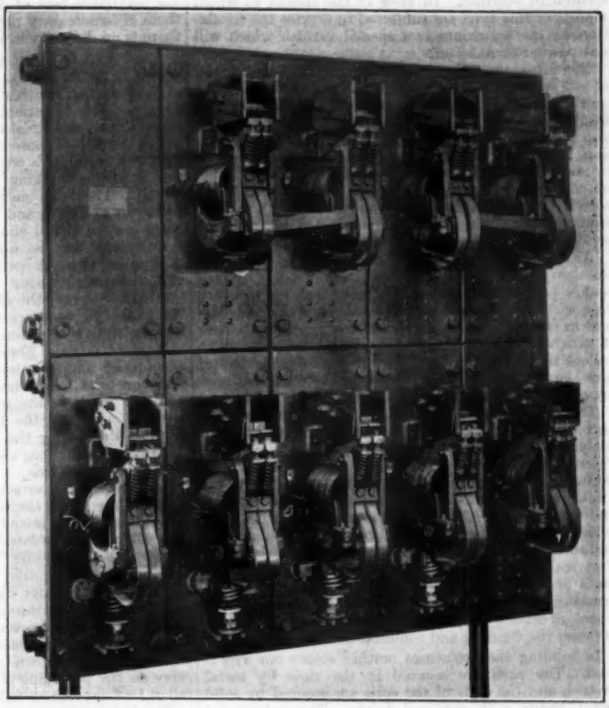

FIG. 7.

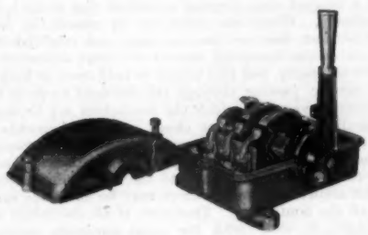

FIG. 8.

THE conditions under which the motors for driving the auxiliary machinery in rolling mills and steel works have to operate are extremely severe. They have to be started, stopped and reversed with the greatest rapidity and frequency, and even when extreme care is observed in the manipulation of the necessary control gear are subjected to heavy and rapidly-fluctuating overloads. Moreover, motors for this class of service are often located in confined spaces where facilities for ventilation and the radiation of heat are extremely restricted, and on account of the large amount of dust and fine particles of mill scale suspended in the air it is necessary that their working parts should be totally enclosed.

These and other conditions familiar to steel works' engineers can only be met by special design, and to this end the British Thomson-Houston Company, Limited, of Rugby, have brought out a complete line of new mill-type (MD) motors specially designed to meet them and ensure continuity of service. Fig. 1, on page 570, shows a set of such motors intended to be used in connection with the rolling-mill which is included in the photograph.

The new mill-type motors range in capacity from 3-h.p. to 150-h.p., and are designed for use on both 230-volt and 550-volt continuous-current circuits. They are rated for a temperature rise of 75 deg. C. after a continuous run of one hour at full load, and are liberally proportioned both electrically and mechanically. They will carry loads which vary instantaneously between light load running and 100 per cent. overload with black commutation and much greater overloads may be carried without injurious sparking or the development of unduly high mechanical stresses. Their design embodies a number of special features to facilitate rapid replacement of any part that may be damaged, and the nature of the insulating material used is such that they can be run safely in temperatures up to 150 deg. C. for considerable periods.

The general appearance of these motors is indicated by Fig. 2, which shows one of the smaller machines. It will be seen that they are totally enclosed in steel frames which are split horizontally. The lower half of the frame is provided with four heavy feet, each drilled for one foundation bolt, and stability and freedom from vibration are ensured by the wide spread of the feet. Wrought-iron bails cast into the upper half of the frame provide a convenient means of handling the motor. There is a large opening in the frame directly over the commutator and brush gear, which are easily accessible. In the larger sizes other openings are provided. All the openings have malleable-iron covers fitted and held in place by locking levers. The frames of the 40-h.p., 60-h.p. and 80-h.p. motors are hinged so that the upper parts may be turned back: this is a valuable feature where space is restricted, as it generally is about a mill.

The bearings are cast with the frame, and are, therefore, always in true alignment. The bearing liners are of cast steel filled with babbitt metal, and the two halves of each liner are bolted together. The upper half of each liner is cast with a lifting ring, as shown in Fig. 3, and it is thus possible to remove the armature and shaft and replace them immediately with a complete spare unit without delay or the provision of any special lifting tackle. Each bearing is provided with two oil rings to ensure continuous lubrication.

The main pole pieces are built up of steel punchings riveted together and secured by bolts passing through the frames, and the commutating poles are held in place by tap bolts. The poles and frame are so arranged that it is not necessary to slacken or remove any of these bolts or disturb the poles in any way when it is desired to lift the upper half of the frame. This is clearly shown in Fig. 3. Neither is it necessary to disconnect any leads inside the motor, for all connections between the two halves are made by sleeve couplings outside the frame.

In the smaller motors the field coils are wound with asbestos-covered wire. The field coils of the larger machines are of copper strip wound on edge, with sheet asbestos between the turns. The entire coil is finally covered with sheet mica and a heavy wrapping of asbestos tape in every case. All main and commutating coils are duplicates, and may be put on the pole pieces either side up without any chance of confusion or wrong connections; it is only necessary to connect alternate coils oppositely in an entirely obvious manner.

In view of the extremely heavy service for which these motors are designed, the shafts and bearings are exceptionally large, and the mechanical construction of the armatures is of the most substantial description. The armatures are built up on strong spiders and the punchings assembled under heavy hydraulic pressure. The front flange is held in place by a shoulder on the spider and the rear flange by four or more fitted bolts with nuts and special locking devices. The space blocks in the armature cores are of small-channel steel,

specially rolled and drawn for the purpose, and each welded to the adjacent punching. In order to secure an absolutely tight core the punchings are assembled so as to vary the lay of the iron in such a way that the last punching will be true and the pressure on the core will therefore be uniform when the flanges are secured in position. In view of the shocks to which motors of this type are subjected in service the insulation on the punchings is a special varnish which will not powder or flake off.

The armature coils of the smaller motors are formed of asbestos-covered wire. They are wrapped with mica and a covering of asbestos tape, after which the slot insulation is put on and the whole then compressed to size in steam-heated moulds. The result is a strong and solid coil free from air spaces and not easily injured. In the larger machines the coils are formed of copper bars continuous at the rear end and the soldered clips used on ordinary motors are thus eliminated. The insulation and method of moulding the solid coils are the same as for the smaller machines.

An important feature of these motors is the use of the two-circuit series drum or wave winding, which makes possible the use of two brush holders in every case where the current is such as to make this possible, and in the case of the larger 230-volt machines, where it is necessary to use more than two brush holders to collect the heavy currents, does not involve the use of any equaliser rings or cross-connections between commutator segments.

The commutator bars are of hard-drawn copper, and are formed with ears which extend to the full diameter of the armature. The armature conductors extend straight into the ears, so that separate commutator leads are eliminated, and there is only one joint for each connection between armature winding and commutator. These joints are made with hard solder. The bed insulation and cones are of clear mica, and the clamping rings are secured by large bolts, so that really tight commutators are secured. The commutator shell is mounted on an extension of the armature spider, so that the shaft may be removed when necessary without breaking the connections between the winding and commutator.

In banding the armatures neither solder nor wire is used. The coils are secured in the slots by metal wedges, and the ends of the coils are secured by solid metal bands with cottered joints. The substantial nature of these fastenings is shown in Fig. 4. The ends of the armature windings are protected from injury by the commutator ears at one end and at the other by an extension of the end flange. Fig. 5 shows very clearly the exceptionally large size of the shaft and the sturdy construction of the armature and commutator. The finished armature is carefully balanced, although on account of its heavy construction and low peripheral speed this is not really necessary.

In view of the importance of extremely rapid acceleration the armatures have been made small in diameter, and the peripheral speeds are low, as compared with those of many continuous-current motors. As a result the power required to accelerate an MD motor to full speed in a given time is only one-third to one-fourth of that required for a direct or alternating current motor of usual design and the same power.

The brush holders are of the clock-spring type, with phosphor-bronze springs. They are of sturdy and simple design, and quite accessible. They can be easily and quickly removed or replaced, and can only be replaced in the correct position.

Although primarily intended for driving live roller gear, lifting tables, and similar exacting duties, these motors may be used with advantage for ingot stripping and ladle cranes, charging machines, and in other cases where reliability and continuity of service are essential.

The use of ordinary tramway type or other hand-operated non-automatic controllers for the motors which drive live roller gears and similar machinery results in excessively severe current rushes, which sooner or later involve injury to the armatures or breakage of shafts or pinions. These breakages, and the annoying and costly stoppages they entail, can be obviated to some extent by slow and careful handling of the controllers. It is obvious, however, that if the operator exercises sufficient care he will not be able to concentrate his attention on the manipulation of the ingot or billet, and the rate of working will be much slower and the output of the mill considerably less than it would be if he were able to devote his attention entirely to the prompt and rapid execution of his primary duty.

The disadvantages attendant on the use of the hand-operated controller can be avoided entirely by the use of the automatic contactor control gear with current limiting attachments which has been specially designed and developed for this class of service. This gear relieves the operator of all responsibility for slow and careful handling of the controller and limits the current at all times to the maximum value the motor can safely carry. The acceleration or reversal of the motor is, therefore, effected with absolute safety at the maximum rate consistent with the mechanical and electrical capacity of the motor, and very much quicker than is possible with the most highly skilled manipulation of the ordinary type of controller. The use of automatic control gear enables the attendants to work the mill at the maximum rate of output possible, and so relieves them of unnecessary physical and mental exertion that there is no difficulty in maintaining this state of affairs.

A set of control gear of this type includes a contactor panel, as shown in Fig. 7, page 579, and a suitable set of resistances, together with the controller shown in Fig. 8. The electrical connections between motor, control gear, and resistances, are shown in Fig. 6, from which it will be noted that four of the electrically operated switches or contactors, viz., Nos. 1, 2, 3 and 4, are used for making and reversing the armature circuit. These are mechanically interlocked in pairs, as shown in Fig. 7, and in such a way that only two of them can be closed simultaneously. It will be noted that current for the operating coils of Nos. 1 and 3 is supplied through controller-finger F, and for Nos. 3 and 4 through finger R, and that the mechanical interlocks prevent the closure of No. 1 and No. 3 until No. 2 and No. 4 are open, and *vice versa*, and so obviate the possibility of serious short circuits such as might otherwise occur. These four contactors are non-automatic, and are used for connecting the motor armature and field windings across the line in series with the whole of the resistance. The resistance is so proportioned that the motor may be "plugged" or stopped by turning the controller to the first stop in the reverse direction, and so applying reverse current of suitable magnitude.

The remaining contactors, Nos. 5, 6, 7, 8 and 9, are for short-circuiting the resistance by steps. Operating current for No. 5 is supplied through finger 2 of the controller when the latter is in a position intermediate between the "plugging" and full-speed positions, and the motor is required to run at reduced speed. Operating current for closing contactors Nos. 6, 7, 8 and 9 is supplied through finger 3 of the controller when the latter is thrown right over to the full running position in either direction, but the closure of each of these contactors in turn is delayed by a current limiting relay on the preceding contactor until the current has fallen to a prescribed value.

The current limit relays each consist of a solenoid and a magnet core carrying a contact disc at its lower extremity. When the contactor is closed the core and contact disc are free to drop and establish the circuit of the operating coil of the next contactor in order of closing, but this circuit is held open as long as the current passing through the solenoid exceeds the prescribed value at which the contactors are to close. Immediately a contactor closes and short-circuits a section of the resistance the current rises to a maximum value, and by suitably proportioning the resistances the ratio of this maximum to the minimum current, which allows the relay to drop, may be made the same for all the contactors. Therefore, if all the relays are arranged to close with the same minimum current, the maximum currents will all be equal, and may be made as great as the motor will carry safely. When these conditions are satisfied, acceleration and reversal will take place in the minimum time without any special effort on the part of the attendant.

Motors for driving live rollers have to be started, checked, started again or reversed, as often as 20 to 30 times a minute, and as the average working day in rolling-mills is 20 hours, it is evident that the contactors and relays must be of thoroughly robust construction, both electrically and mechanically. That this is the case may be seen from Fig. 8, which shows a single contactor with its mechanically interlocked current-limiting relays.

The controller, although small and light, is of the same substantial construction as the larger tramway-type controllers made by the same firm, and, as mentioned above, has three points for each direction of rotation, viz., a checking point on which a comparatively large resistance is connected in circuit to limit the rush of current when the motor is checked or reversed, a slow-running point used for manipulating the ingots or billets, and a full speed point. Only the small current required for the magnet coils of the contactor passes through the controller, and the wear and tear of the fingers is therefore very small. The current supplied to the motor is controlled entirely by the contactors, which are fitted with heavy renewable copper contacts and also provided with powerful blow-out coils. The strong magnetic fields so produced, and the exceedingly rapid make and break of the contactors, results in the instantaneous suppression of arcing and burning of the contacts, such as takes place in hand-operated controls. The life of the contacts is therefore long, and at the same time they are so designed that they may all be replaced in a few minutes.

The design and construction of both motors and control gear is an effective insurance against those annoying failures and delays which have such a marked effect in cutting down the output of rolling mills and steel works.

METAL MELTING.*

By H. M. THORNTON, M.I.Mech.E., and HAROLD HARTLEY, M.Sc.

THE MELTING OF BRASS AND COPPER IN A CRUCIBLE FURNACE WITH COAL-GAS FUEL.

THE marked success achieved by furnaces employing coal-gas as a fuel, in the heat treatment of metals such as steel, is proving of material assistance in the introduction of gas-fired, metal-melting crucible furnaces. Although it would be premature to claim that these latter are fully established, nevertheless, as will be seen from the data to be given later, they offer great possibilities.

It is proposed in this communication to deal only with a furnace of the type intended for melting the metals of higher melting-point from brass upwards, as we feel that in this direction coal-gas and water-gas are especially capable of giving the desired results.

General Considerations.—In working with coal-gas the fact must not be overlooked that in terms of British thermal units available the fuel is costing from four to five times as much as coke. Starting with this disadvantage the furnace manufacturer has either to obtain a markedly greater thermal efficiency out of his appliance or to effect economies in other directions. It is probable that the cast metal prepared with the gaseous fuel would give better results than that obtained by coke melting in those cases where sulphur content is an important factor.

Fuel Consumption.—Just as in the case of solid fuel, this is determined with a given furnace by the specific heat of the solid metal between the temperature of the atmosphere and the melting-point, the latent heat of fusion, and the specific heat of the molten metal. The effect of this latter factor may be very important where a high degree of fluidity is desired for any specific purpose.

Temperature of Molten Metal.—When asked to quote fuel consumptions, the furnace manufacturer may feel himself in somewhat of a quandary unless the melter can provide some fairly precise information as to the pouring temperature required, and in the test data given later we have included the temperature of the metal before pouring, just before the crucible was lifted out of the furnace. These temperatures were obtained by means of a Pt/PtRh thermo-couple.

In our work with brass and copper the pouring temperature has ranged about 100 deg. C. to 150 deg. C. above the liquidus. In this connection it is of interest to recall the work of J. M. Lohr, published in 1913 and abstracted in the Institute Journal, in which the conclusion is drawn, after an examination of the copper-zinc alloys, that the best pouring temperature is between 100 deg. C. and 200 deg. C. above the liquidus, a higher pouring temperature always producing an oxidised casting. Longmuir's work† also indicates that very hot metal does not give the best results.

Certain workers advise raising the temperature of the metal to a point in excess of that necessary for casting, and then after drawing the crucible from the furnace holding for a sufficient length of time until the mass has cooled to a suitable extent. We notice, however, in a recent article on this subject,‡ that it is stated, with reference to brass melting, overheating is not advisable, as there is always the danger that it will lead to honey-combing, which is not completely avoided if the metal is cooled before pouring.

Turner and Thorneycroft state§ that considerably more heat is required to liberate zinc from alloys rich in copper than to volatilise the liberated zinc, and they give the ratio of the amounts of heat required for the processes as 94 : 6 as a first estimate. On the basis of these figures, the temperature rise caused by the addition of zinc to molten copper can be calculated. A considerable rise of temperature occurs. The addition of zinc to molten yellow brass does not appear to cause a rise in temperature of the mass, nor does it appear to arrest the cooling of the metal. The following temperature determinations were made on plunging zinc in lump form into 70 lb. of molten yellow brass (70 per cent. copper) :—

Time (mins.).	Temperature. deg. C.	
0	1,132	
1½	1,115	(1 lb. of zinc added)
2	1,108	
3	1,088	(1 lb. of zinc added)
4	1,062	

In an abstract in the Journal of the Institute for 1914 is given a list of various commercial brasses, with the temperatures at which they pass completely into the liquid state.‖ From this list the following are taken :—

Metal.	Cu.	Zn.	Sn.	Pb.	Melting-Point.
Gun-metal	88	2	10	—	995
Red brass	85	5	5	5	970
Half yellow }	75	20	2	3	920
Half red }					
Cast yellow brass	66.9	30.8	—	2.3	895
To these we add :—					
Copper	—	—	—	—	1,084
Copper, 3.5 per cent. cuprous oxide	—	—	—	—	1,065

* Paper read before the Institute of Metals, slightly abbreviated.

† Journal of the Iron and Steel Institute, 1903 and 1904.

‡ *Metal Industry*, October 13, 1916.

§ Journal of the Institute of Metals, 1914, vol. xii.

‖ Gillett and Norton, *Metal Industry*, 1914, vol. vi.

Brass Melting.—Starting from cold a certain amount of energy is required to heat up the bodywork of the furnace, and the additional fuel needed for this purpose acts as a handicap in the endeavour to obtain low average consumptions, the over-all effect of which is decreased by increasing the number of melts carried out successively. For the fourth and subsequent melts it is found generally that the gas consumption per lb. of metal melted remains practically constant. In the last melt of the day a small saving is effected, owing to the fact that there is no excess of brass in the metal preheating chamber, and in consequence the degree of preheating of both the metal and air increases. If time will allow it is possible to increase this saving by a judicious checking of the gas supply and consequent abstraction of heat from the furnace walls, as the combustion chamber will be considerably hotter than the crucible and its contents.

Below are given results of a typical run, limited to six melts to avoid repetition, and added are the average consumptions on the basis of 12, 15 and 20 melts.

BRASS MELTED.

(General scrap and ingots obtained previously from mixed scrap. For approximate composition see "Original Metal," later.) Brass and air preheated.

No. of Melt	1.	2.	3.	4.	5.	6.
Weight of metal charged (in lb.)	68	68	68	68	68	68
Including scrap	8 lb. 14 oz.	3 lb. 15 oz.	2 lb. 9 oz.	6 lb.	7 lb. 10 oz.	6 lb. 11 oz.
Amount of metal preheated	12	All	All	All	All	All
Gas:						
Cubic feet per lb. metal melted	4.93	2.09	1.78	1.66	1.60	1.40
Calorific value, net	554.8 British thermal units per cubic foot.					
British thermal units per lb. melted metal	2,644	1,121	955	891	858	751
Pouring temperature	990 deg. C. to 1,010 deg. C.					
Duration of melt (in minutes)	86	38	34	31	31	30
Weight of skimmings	10 lb.					

Sawdust added to decrease oxidation. No flux used. No zinc added prior to pouring.

Summary.

	Gross Consumption per lb. Metal Melted.	B.Th.U. per lb. Metal Melted.
	cub. ft.	
Average for 6 melts	2.25	1,203
,, ,, 12 ,,	1.92	1,031
,, ,, 15 ,,	1.86	996
,, ,, 20 ,,	1.79	962

If it be desired to raise the temperature of the brass 100 deg. C. higher than that in the above test, then it is estimated that the gas used per lb. of metal melted would be increased by 20 per cent.

Metal Losses.—The weight of dross is sometimes unduly swelled, owing to the moulder putting his skimmer too deeply into the metal, and this we find more often to happen when no flux has been added to form a protective covering.

To some extent opinion would appear to be divided on the question of the desirability of employing a flux in brass melting, and no doubt the decision taken in many cases is largely determined by the final temperature required. When it is intended to work with very hot metal it may be thought to be advantageous to use a flux, on the ground that it would form a more impervious covering than charcoal and thus lessen the volatilisation of zinc. When a flux is used the weight of metal cast appears to differ less from the weight of metal charged than when only charcoal is used, due apparently to brass becoming intermingled with the charcoal in the latter case. Analyses, to which attention will be called later, of two brasses remelted several times (*a*) with a sawdust covering, (*b*) with common salt as a flux, indicate that the loss of volatile constituents is much the same even when the metal is rendered very hot. In the same series of tests the weights of dross withdrawn from the pot were :—

(*a*) From 1 lb. 4 oz. to 1 lb. 8 oz. per melt.
(*b*) 14 oz. in melts 1 to 4, 8 oz. in melt 5. Weight of salt added originally, 4 oz. per melt.

McWilliam and Longmuir* state that "the best quality alloys are always produced without fluxes, and extensive experiments in this direction are not at all favourable to any type of flux during melting."

In an article dealing with the manufacture of cartridge brass C. R. Barton† recommends the use of common salt as a flux and phosphor copper as the deoxidiser in crucible melting, and further mentions that this type of furnace is preferred for the work despite the relatively high cost of crucibles, which, he says, have on the average a life of 25 melts (200-lb. to 220-lb. size) in coke-fired furnaces.

For ourselves, we find a certain amount of inconvenience attached to working with a salt covering, owing to the acid fumes produced. This flux appears to attack the crucibles markedly, and if thrown into the furnace at all carelessly may be blown into contact with the outside of the pot and rapidly end its days. Deterioration of the firebrick lining due to the salt would depend apparently on the temperature of the furnace when the salt came into contact with the walls. If the fireclay was hot enough to form a glaze at once no great trouble would be anticipated ; on the other hand, if the temperature were lower and the NaCl vapour had an opportunity of diffusing into the brickwork and reacting with it later, the result would be unpleasant.* On the other hand salt is stated† to be useful in small quantities, admixed with charcoal to prevent absorption of sulphur by molten copper and its alloys ; and to lessen the retention of viscid metal by the dross. The fluxes used more generally are calcium fluoride, glass and potassium hydrogen sulphate.

We ourselves incline to the view that the most satisfactory results are obtainable by the use of a charcoal or similar covering, together with a small amount of flux. In an inert atmosphere the rate of loss of zinc from a given brass will depend on the temperature and the speed of flow of the gases over the metal. During melting the process may be accelerated, owing to the oxidation of the zinc vapour and consequent reduction of the partial pressure of the metallic vapour. The effect of this latter factor is decreased to some extent if the combustion of the gases is not completed in the pot chamber, and still further if a covering of charcoal is employed. In the final heating stage, after the metal is molten and when the greatest loss occurs, a crucible lid previously heated in the metal preheating chamber can be used to cover the pot and decrease the loss. Assuming that it requires in the respective furnaces 3.0 cub. ft. of coal-gas, or 0.5 lb. of coke per lb. of metal melted ; then if the gas is burnt completely to CO_2 in the pot chamber the volume of products (calculated at 0 deg. C. and 760 mm.) will be about 14 cub. ft., whereas with the coke if it burns to CO_2 there would be about 77 cub. ft. of products, and if only CO were formed, about 45 cub. ft. From three to five times the volumes of products flowing through the gas-fired furnace pass through the coke furnace.

In brass melting in coke crucible furnaces the zinc loss is stated often to be large, in which case it must be an important factor, both from the economic point of view, which is of especial moment at present, and, unless corrected for prior to pouring, with regard to its effect on the mechanical properties of the resulting alloy.

Statements have been published that in the process of melting brass, as generally carried out, about 20 per cent. to 25 per cent. of the weight of zinc originally added is lost ; compensation is made for this by plunging a piece of spelter into the molten bath and involves a still further loss of metal.

McWilliam and Longmuir cite the case of a manganese bronze which they remelted in a crucible furnace (coke ?) to determine the zinc loss. They give the following analyses‡ :—

	Original Metal.	Remelted and Sand Cast.
Copper	59.00	68.88
Tin	0.58	0.86
Zinc	37.92	28.13
Iron	1.40	1.45
Manganese	0.42	0.23
Aluminium	0.48	0.20

Unfortunately no details are given of the period of heating or of the temperature attained. It will be noticed that the zinc loss is about 25 per cent., and the manganese loss about 50 per cent. Further, these authors state that they estimate the original metal would have a maximum stress of 25 tons to 28 tons per square inch, whereas the remelted metal would not sustain more than 15 tons per square inch. They also gave a series of results showing the losses in making different brasses "in typical crucible furnaces" : these vary from 28.6 per cent. in the case of red brass when a temperature of 1,308 deg. C. was attained, to 19 per cent when making Munts metal, the maximum temperature in this latter case being 1,038 deg. C.

We have investigated this point in connection with gas-fired furnaces, and although anticipating some saving, the great difference between our results and those of the authors just quoted cannot be put down solely to the credit of the gas furnace. The high loss of zinc in the remelting of the above manganese brass is conceivably due, in part at least, to the presence of the β phase in that particular sample, as Thorneycroft and Turner§ have shown that the β alloys part with zinc much more readily than the α solutions with which we were concerned. Further, according to Thorpe's Dictionary,‖ 5 per cent. represents the maximum loss of zinc usually experienced in the making of brass when the volatile constituent is added to the copper in large pieces.

H. W. Gillett* states that in current practice of brass melting 5 per cent. of the original metal is lost ; later he says that reports of metal losses vary from 1 per cent. to 22 per cent. Recently, in making up a red brass containing a little tin in four 50-lb. lots, we found the average zinc loss not to exceed 3.0 per cent.

In connection with the determination of zinc loss on remelting yellow brass, the following tests were made. Two 70-lb. lots of works scrap brass A and B were melted and cast into chills, sample ingots being retained for analyses. Batch A was then remelted with a covering of sawdust only, cast into ingots, a test ingot withdrawn, and the remainder returned to the crucible, remelted, and a further sample taken. This treatment was repeated, five remelts in all being made. In the last melt, after the pourers had approved the metal to be sufficiently hot for casting purposes, the crucible was left in the furnace for another half-hour, the temperature of the metal being raised steadily during the whole of this period.

The second batch of metal B was treated in a similar manner, except that in this case a covering of common salt was employed, and no provision of charcoal made for the prevention of oxidation. In neither case was a crucible lid used. The analyses of the various ingots withdrawn during the series are given below. These test ingots weighed about 3 lb. each.

Variation in Composition on Remelting Brass Repeatedly.

	Original Metal.	Remelts. 1.	2.	3.	4.	5.
Copper (by difference)	70.57	71.44	71.76	71.67	71.54	73.27
Zinc	24.77	24.65	24.45	24.15	23.63	22.14
Tin	1.34	1.24	1.19	1.15	1.38	1.29
Lead	2.90	2.22	2.04	2.60	2.92	2.75
Iron	0.33	0.45	0.56	0.43	0.52	0.55
Duration of heating period (in minutes)	—	122	44	40	30	53
Pouring temperature	—	990 deg. C. to 1,015 deg. C.				1,180 deg. C.
Weight of skimmings ... oz.	—	21	22	24	24	24

	Original Metal.	Remelts. 1.	2.	3.	4.	5.
Copper (by difference)	70.01	70.24	70.29	70.50	71.08	72.45
Zinc	45.97	24.97	24.72	24.46	23.90	22.68
Tin	1.30	1.21	1.24	1.30	1.37	1.29
Lead	2.78	3.12	3.19	3.29	3.27	3.12
Iron	0.62	0.46	0.54	0.45	0.32	0.46
Duration of heating period (in minutes)	—	95	40	34	29	58
Pouring temperature	—	990 deg. C. to 1,015 deg. C.				1,180 deg. C.
Weight of skimmings ... oz.	—	14	14	15	14	8

Zinc Loss during Remelting : per cent. Zinc present Originally.

Melts No.	0 to 1	1 to 4	4 to 5
	Per cent.	per cent.	per cent.
Series A	0.48	4.26	6.19
Series B	1.34	4.04	5.63

The loss occasioned by heating to 1180 deg. C. was about 4¼ times the average loss in each of the preceding melts.

(*To be continued.*)

GERMAN "SUBSTITUTES."—We read so much of the German aptitude for the employment of substitutes, in order to minimise the inconvenience caused by our blockade and the shrinkage of their economic resources, that it is interesting to read in their technical literature that these substitutes are not always satisfactory. An instance of this kind is recorded in the *Zeitschrift des Vereins deutscher Ingenieur*, April 19, 1917. The case under consideration is the trouble created by the use of soap substitutes. These consist of preparations made from precipitated clay, China clay, and slaked lime, which, while they are said to be fairly efficient substitutes for soap, seriously impede the domestic drainage system. It has frequently been found that the house mains become obstructed, particularly at the point of junction with the street mains, by a white, pasty sediment, and the only remedy in most cases is the laying bare and opening the drain pipes to remove the obstruction. The mass thus removed is found to consist of clay and lime mixed with fibrous matter of vegetable nature which consolidates into a tough paste. In order to prevent this nuisance it has been suggested to the householders that slops should not be emptied into the drainage system till the remainder of the sham soap has accumulated at the bottom of the pail. This tedious and objectionable process, which, by the way, would not be observed by the average domestic, appears to be the only feasible remedy, the alternative being to provide accessible settling chambers in the domestic mains, and these cannot be installed owing to the present shortage of labour. This trouble might lead to serious consequences and is undoubtedly quite an unthought-of sequence to the shortage of fats.

* "General Foundry Practice," 2nd edition, page 328.
† *Journal of the Society of Chemical Industry*, July 15, 1916, page 740.
* Cobb, "Effect of Salty Coals on Coke-oven Linings," *Journal of Gas Lighting*, March, 1916.
† *Metal Industry*, February 23, 1917. Abstracted from *Brass World*.
‡ *Loc cit.*, page 360.
§ *Loc. cit.*
‖ Vol. v, page 816, "Cast Brass."
* *Bulletin of the United States Bureau of Mines*, 1914.

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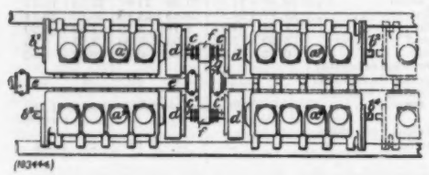
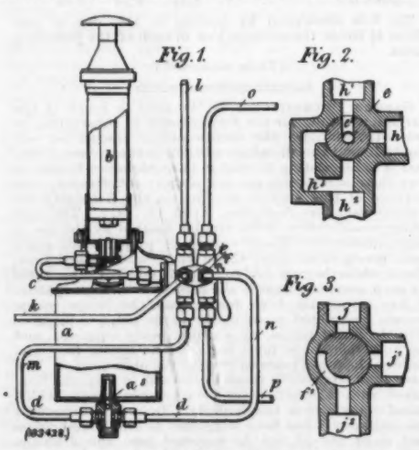
GAS ENGINES, PRODUCERS, HOLDERS, &c.

103,444. A. W. Boothroyd, Lexden, and A. G. Mumford, Limited, Colchester. Internal Combustion Engines. (1 *Fig.*) July 31, 1916.—This invention relates to an improved disposition and arrangement of groups of internal combustion engines and transmission mechanism of the type in which multi-cylinder engines are employed, in which said engines are arranged in groups, and in which all the engines drive the same transmission shaft. The internal combustion engines are arranged, according to this invention, in groups of four or multiples thereof, the units being arranged in two pairs side by side, and in parallel relation to one another, a common transmission shaft being mounted centrally between the two pairs of engines, the crankshafts of each pair of engines being coupled to the common transmission shaft by means of an intermediate shaft—lying axially between the



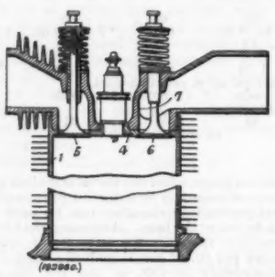
crankshafts—and a single train of gearing and a clutch coupling being provided between the crankshaft of each engine of each pair and the common transmission shaft. a^1, a^2, a^3 and a^4 designate four multicylinder internal combustion engines forming the units of a group, b^1, b^2, b^3 and b^4 the crankshafts of said engines, c and c^1 the intermediate shafts between the crankshafts b^1, b^2, b^3 and b^4, d the clutches arranged between the crankshafts of the engines and the intermediate shafts, which are preferably of the combined friction and positive engagement type, e the common transmission shaft, f spur wheels fixed on the intermediate shafts which gear with a spur wheel g fixed on the transmission shaft, said spur wheels being preferably of the double-helical type. (*Sealed.*)

103,428. F. H. Royce, E. W. Hives, and Rolls-Royce, Limited, Osmaston, Derby. Internal Combustion Engines. (3 *Figs.*) June 26, 1916.—This invention consists of a priming device for internal combustion engines driven by the vapour of liquid fuel consisting of a U-shaped passage in communication with a liquid fuel supply tank, other than the float tank of the carburettor, by means of a suitable port, with or without a non-return valve, in such a manner that liquid will flow by gravity into the U-shaped passage, a connection between one side of the U-passage and the induction pipe of the engine terminating therein in a spraying nozzle, an air pump in direct communication with the other side of the U-passage and means for making or cutting out connection between the U-passage and the induction pipe or pipes. a denotes the body of the liquid fuel reservoir, to which is fixed the air pump b. The air-pump valve



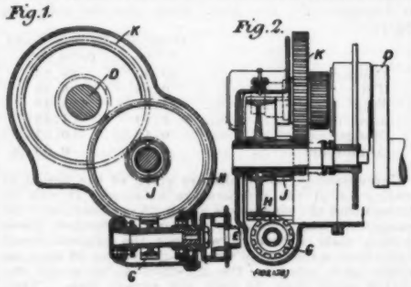
is connected to the pressure pipe c. In the base of the reservoir is fitted a non-return valve a^3, which permits the liquid in the reservoir passing into the supplemental chamber d in the form of a U-shaped tube until such liquid assumes the level of the liquid in the reservoir. The distributing valves e and f are fixed to the cover of the reservoir. The spindle of the valve e is formed with a passage-way e^2, partly axial and partly radial, by which, on rotation, the pipe c can be put into connection with any of the ports A, A^1, or A^2. The spindle of the valve f is formed with the circumferential passage f^1, by means of which connection can be made between ports j and j^1 or j^1 and j^2. With the spindles in the positions shown, the air pump is in connection with the pipe l. By rotating the spindles clockwise 90 deg., the air pump would be in connection with the pipe k, and by rotating the spindles 90 deg. further the air pump would be in connection with the pipe m, the supplemental chamber d and the pipe n, and hence the supplemental chamber would be in connection with the pipe o, and by rotating the spindles 90 deg. further the air pump would be in connection with the pipe m, the supplemental chamber and the pipe n, and hence the supplemental chamber would be in connection with the pipe p. It will be observed that when the air pump is in communication with either of the pipes l or k, the priming pipes o and p are cut out. Pipes l and k may be connected up to the main liquid fuel tank or tanks or used for any other suitable purpose where air pressure is required. It is possible to arrange this mechanism without a non-return valve in the base of the reservoir, but the same would not work so efficiently when priming owing to the escape of pressure through the liquid in the reservoir. (*Sealed.*)

103,960. The Daimler Company, Limited, and A. E. Berriman, Coventry. Internal Combustion Engines. (1 *Fig.*) September 9, 1916.—The object of the invention is to improve the construction of the cylinders of internal combustion engines. According to this invention, the cylinder 1 is composed of a barrel closed at one end by a partition 4 integral with the barrel and flat on its outer face, the said barrel being free from any integral external flange at the partition end, and therefore externally cylindrical. The said partition integral with the cylinder barrel is ported with holes for the valves 5, 6, which may have their seats formed on the inner face of the said partition, and such a cylinder may be conveniently machined from a solid steel forging or bar, and the wall be made exactly to the dimensions specified on the drawing of the design and will be uniformly accurate in this particular to a degree that is not readily attained



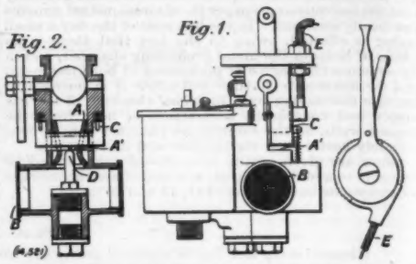
in any other way. With such a cylinder according to this invention a casting 7, which is preferably of aluminium, is provided which embodies the valve chamber and pipe attachments required for the admission and exhaust of the gas from the cylinder. The said casting is formed with a flat face which fits in surface contact upon and covers the flat external face of the integral partition 4 of the cylinder and ports formed in the flat face of the casting register with the valve holes in the cylinder head partition, intimate contact existing between the two faces, namely, between the entire face of the valve chamber casting and the flat and unobstructed face of the cylinder head. The two flat surfaces of the valve casting and the integral cylinder head are held in intimate contact by bolts extending from the valve chamber casting to the crank chamber. (*Sealed.*)

103,158. Sunbeam Motor Car Company, Limited, and L. Coatalen, Wolverhampton. Internal Combustion Engines. (3 *Figs.*) January 18, 1916.—This invention relates to starting mechanism or turning gear for internal combustion engines. Accordingly, the patentees employ a starting shaft E which projects at right angles to the engine shaft D and drives the latter through intermediate gearing comprising a pair of plain



wheels J, K adapted to mesh automatically when the starting shaft is rotated, and a pair of helical gears G, H which provide the right-angle transmission. Of these helical gears G, H, the driven element H is broad and is free to slide so that when the starting shaft E is first rotated the driven helical gear H moves laterally, engaging the spur gears J, K. Continued rotation causes the engine shaft to be driven round. (*Sealed.*)

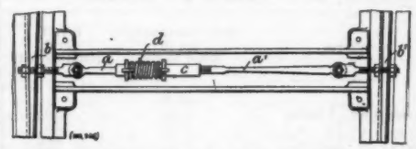
14,521/15. S. Wertheimer, London, and B. A. Cole, Harrow. Carburettors. (4 *Figs.*) October 14, 1915.—This invention refers to carburettors provided with "choke" tubes or chambers, which may be arranged vertically or horizontally. In accordance with the present invention, provision is made for supplying the air desired to the fuel around the jet or jets in the choke tube or chamber, that is to say, at the part where an intimate mixture of air and liquid will be ensured, and means are also provided for readily and easily varying the proportion of air in the combustion mixture at will. The carburettor illustrated, to which the present invention is shown applied, is one in which the choke tube A is disposed vertically, and which has the usual air inlets B through which air will be drawn in, in accordance with the suction action of the engine. According to the embodiment of the invention shown, to provide for an additional controllable air supply the body of the tube A, which is a fixture or is stationary, is open or cut away at A^1, so as to leave at A^1 an opening or space above the bell-shaped or usual inlet passage B and contiguous to the jet D or jets, and this cutaway or open portion A^1 is enclosed or encircled by a sleeve C which can be moved or adjusted relatively to the jet D. The member C is mounted to move on guides on the outside of the choke tube A, and also its enclosing tube where such is used. The sleeve C thus controls the size of opening contiguous to the fuel jet and the amount of air that can enter at this part, and by adjusting the sleeve C the amount of air entering can be varied at will, and in accordance with the requirements of the running conditions of the engine. In accordance with the invention, the adjustment of the tube and the size of the air inlet can be effected readily and quickly and without necessitating the driver of the car leaving his seat, and a convenient means for accomplishing this, as applied to the adjustable sleeve C shown, comprise a "Bowden"



wire or cable E. The sleeve C has slots, through which project headed studs or screws secured to the body of the tube A. The "Bowden" cable is operated in the usual way by a lever, to which one end of one member of the Bowden cable is secured, and one end of the inner member of the cable is attached to the sleeve C and the similar end of the outer member of the body of the carburettor, so that the sleeve C moves on the guide studs. (*Accepted January 24, 1917.*)

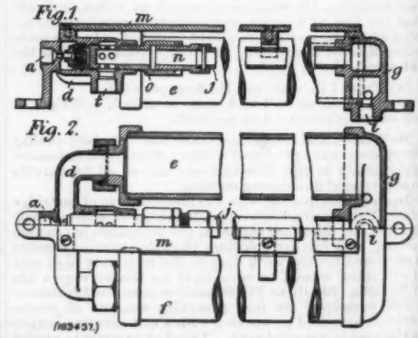
RAILWAYS AND TRAMWAYS.

103,236. R. B. Holt, Leeds. Points. (2 *Figs.*) April 26, 1916.—The invention relates to means for connecting the tongues of double or twin points, which, according to the usual practice, is effected by means of a rod secured to each tongue. The invention consists in an improved form of connecting rod. The improved connecting rod is constructed in two lengths a, a^1, each of which is secured to one of the tongues b, b^1. The inner end of the rod a^1 is screwed to engage with one end of a tube c, in which the inner end of the other rod a is free to move. A coiled spring d encircles the tube c and is held in place thereon by means of split keys which



pass through slots formed in the tube c, and also through slots formed in the rod a. These slots are formed sufficiently long to enable any desired amount of compression to be put upon the spring d; it will be understood that the spring d is normally slightly in compression and causes the keys to bear against the outer end of their respective slots in the rod a and in the tube c. With an arrangement constructed as described, both compressive and tensile stresses are borne by the spring d, without any injury or distortion being caused to either portion of the rod, also the rod automatically adjusts itself to any variation of length which may be necessary. (*Sealed.*)

103,437. R. Sawyer, Worthing. Train Heating Systems. (4 *Figs.*) July 20, 1916.—The invention relates to steam heating systems primarily designed for the heating of railway carriages, in which the supply of steam to each radiator is automatically controlled by means of a thermostatic valve in addition to any manual control which may be provided. According to the present invention, means are provided by which any water due to the condensation of steam in the radiator tubes is prevented from passing with the steam through the thermostatic tube. For this purpose, at the header into which the steam passes after traversing the radiator tubes, openings are provided for allowing the water, but not the steam, to escape through a drain pipe. The inlet a leads through a port controlled by a thermostatic valve member to a header d, whence the steam passes in parallel through radiator tubes e and f. The outlets of these tubes connect with a header g, in the webs of which are openings to



convey any condensed steam by a passage to a drain i. The steam traverses a thermostatic tube j, which is of known type and made of a metal, preferably zinc, having a large coefficient of expansion. The tube j is supported at intervals by brackets screwed to a metal strip m, which latter is secured to the headers d and g. In the example illustrated the tube j is screwed and pinned to a co-axial tubular member n, which latter is screwed to a sleeve o supported in a bearing and rendered steam-tight by piston packing rings. The exhaust steam escapes to a drain i. The thermostatic valve member is seated in a cap screwed into the sleeve o; in a thimble screwed to the cap a spring is placed, pressing the valve member against a spherical sealing surface. At a temperature which can be controlled by screwing the cap in or out the linear expansion of the tube j forces the valve member to shut off the supply of steam to the radiator. (*Sealed.*)